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ORIGINAL ARTICLES.

I.—The Carboniferous Succession below the Coal-Measures in North Shropshire, Denbighshire, and Flintshire.[1]

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(With Plates XXI and XXII and five Woodcuts.)

1. Introduction: Description of the Area Examined.

IT requires but little imagination to conceive that a very slight subsidence of the country in North Wales lying between the Vale of Clwydd and the estuary of the River Dee would convert it into a peninsula consisting of Carboniferous rocks skirting to the north, and to the east a strip of Silurian ground. The backbone of this peninsula is composed of Lower Carboniferous rocks, forming the high range which starts from the bold cliffs that border the sandy flats of the north shore of Flint from Dyserth to Talacre. Stretching southwards by way of Halkyn Mountain, Moel Findeg, Nerquis Mountain to Minera and Llangollen, this range, in the main, forms an anticline, off whose eastern flanks the higher divisions of the Carboniferous system dip in natural sequence towards the River Dee.

Rising up from beneath the Vale of Clwydd, the Lower Carboniferous rocks reappear to the west, from the north coast at Colwyn Bay, Colwyn, and Llandulas to south of Ruthin, and in this

[1] This paper was read at the Geological Society on April 4th, 1906. Subsequently the Publication Committee notified us, that unless we were prepared to omit all separate lists of fossils, and show their distribution in one large table at the end of the paper, they could not recommend the paper for publication. As the main object of the paper is to work out the palæontological succession, and as we establish five life zones, we felt strongly that such a course was unfair to us as authors, that it would render the paper useless to those who went over the ground with it. We could not conceive a satisfactory table which would clearly indicate five zones from some hundreds of species collected from some sixty localities. As copious fossil lists had been published in very recent papers in the Quarterly Journal on Carboniferous zones in other localities, we demurred to the differential treatment and withdrew our paper under the conditions required. The paper is in the exact form in which it was read at the Geological Society, with the addition of a discussion on the horizon of the cherts, the interpolation being plainly indicated.

area some of the sections disclose the unconformity between Carboniferous and Silurian rocks. An interesting outlier of Carboniferous Limestone also occurs at Corwen. All the exposures examined by us will be observed to lie in the counties of Salop, Denbigh, and Flint, with the exception of the district of Llysvaen, which is part of Carnarvon.

Usually, the best facilities for collecting were afforded by the numerous quarries which are being, or have been, worked for road metal, iron manufacture, lime, cement, chert, or building stone.

The natural exposures of Carboniferous Limestone forming the picturesque contours of the hills are so completely covered with lichen growth that the fossils are totally obscured, and thus for the purposes of systematic collecting they are not nearly so helpful as at first sight they might seem to promise. In the series of rocks overlying the Carboniferous Limestone the exposures and quarries are comparatively rare, and all those examined by us occur in the tract of country to the north and east of Halkyn Mountain in the county of Flint. At certain horizons the fossils were very abundant, and were of diagnostic value. The Carboniferous sequence of this district, worked out by the aid of palæontological data, has been a much simpler affair than was anticipated. It is not proposed in this paper to do more than indicate the main lines along which this interpretation has been developed; there is yet an immense amount of labour required in order to fill in the intervening details.

2. A Critical Account of Previous Geological Research in the Carboniferous Rocks of North Wales.

Much attention, during many years, was devoted to the study of the Carboniferous succession in North Wales by the late Geo. H. Morton. His various publications extend over the period from 1869 to 1901, when a posthumous paper on "The Carboniferous Limestone of Anglesey" was edited by his daughter.

His work was all done on palæontological lines, but unfortunately he did not recognise any method for the establishment of life zones in the Carboniferous rocks of North Wales. Eventually he established a subdivision of the series founded on the colour of the limestones. One of us had the opportunity, some years ago, of examining the very carefully labelled fossils in his collection, the majority of which are now in the Natural History Museum, Cromwell-road, South Kensington.

All Morton's papers contain elaborate lists of fossils, an examination of which demonstrates that he recognised the important fact that certain beds in various localities had a similar fauna.

His writings also make it very obvious that he had doubts as to the correlation of the peculiar calcareous grits, which, in the south of Flintshire, Llangollen, Sweeney, and Oswestry Racecourse, succeed or replace the purer limestones. There is no doubt that, to some extent, Morton had certain broad palæontological evidence for his subdivision of the thick limestone of North Wales into Upper Grey, Middle White, and Lower Brown, but he did not emphasize the fact.

The choice of the terms is indefinite, for it would lead one to expect the existence of a Lower Grey and an Upper Brown. As far as the nomenclature goes, it would have been much simpler to have inserted the word 'or' between the horizon and its indicative colour.

Moreover, the beds which lie on the Upper Grey Limestone he unfortunately termed 'Upper Black Limestone,' and to this the great source of error in the conception of the sequence, which the officers of the Geological Survey accepted from him, is almost entirely due. There are two or more horizons in North Wales at which Black Limestones occur, just as obtains in Derbyshire, each of which is characterised by a totally different fauna.

The lower set of Black Limestones is worked for hydraulic cement, and is locally misnamed 'Aberdo' Limestone. They are characterised by a fauna typical of the uppermost beds of the Carboniferous Limestone, and contain such characteristic fossils as *Productus giganteus*, *Lonsdaleia rugosa*, *L. floriformis*, *Cyathophyllum regium*, *Amplexi-zaphrentis* sp., and *Cyathaxonia* sp. These corals are only known in beds which form the uppermost division of the *Dibunophyllum* zone of the south-west of England.

The other set of Black Limestones do not yield a hydraulic lime, have peculiar physical characters, weather and fracture in a manner altogether different from the 'Aberdo' stone, and contain a typical Pendleside fauna, *Pterinopecten papyraceus*, *Posidonomya Becheri*, which at once definitely determines the age of the beds to be later than the Carboniferous Limestone Series, and therefore the equivalent of the Pendleside Series of the Midlands. Mr. Morton's lists show that he recognised the fact that *Cyathophyllum regium* and *Lonsdaleia floriformis* only occur in the Upper Grey Limestone in every locality which he examined.

Another important horizon seems to be indicated from Morton's lists. The base of the Lower Brown Limestone is characterised by the presence of that peculiar shell *Daviesiella* (*Productus*) *Llangollensis*, which appears under the name of *Productus comoides* in his lists. We found these two important facts of distribution to be universally true.

The Middle White Limestones we found to be characterised by the presence of *Dibunophyllum* φ and *Cyathophyllum Murchisoni*, fossils which indicate, in the Bristol area, the life zone which immediately underlies the *Lonsdaleia* beds. These two life zones have been named by Dr. Vaughan the Upper and Lower *Dibunophyllum* zones respectively. To a certain extent, therefore, Morton's division of the Limestone Series of North Wales does correspond with that indicated by the palæontological succession.

The Lower Brown Limestone is the lowest member of the series in North Wales, excepting the basement conglomerate, when present, and appears to correspond with the junction of the Upper *Seminula* and Lower *Dibunophyllum* beds of the Bristol area. The Middle White Limestones are practically the equivalents of the Lower *Dibunophyllum* zone of Bristol, but probably a portion of the Upper Grey measures belong to this division. Part of the Upper Grey, the

Upper Black (in part), and possibly some of the cherts equal the Upper *Dibunophyllum* zone of Bristol; while the Black Limestone and Shales of Teilia, Holywell, and Baggilt are the homotaxial equivalents of the Pendleside Series.

Morton classified all the beds which occur between the Carboniferous Limestone and the Coal-measures as Cefn y Fedw Sandstone. He acknowledged, in various writings, his doubts as to the exact correlation and homotaxial equivalents of the several members of the series. The base and the top of the series unfortunately are very variable from north to south, owing to the peculiar and rapid lithological changes which the upper beds of the Carboniferous Limestone Series undergo in this direction, and also to the fact that the Pendleside Series overlying the limestone, although 1,000 feet thick at Holywell, and the Gwespyr Sandstone Series, 300 feet thick, have, if represented near Llangollen, thinned out to a very few feet. Further, Mr. Morton did not recognise that the *Posidonomya Becheri* Limestones of Teilia and Holywell belonged to the same palæontological series, and classed the latter as Coal-measures, in spite of their fossil contents.

Morton, however, recognised the important fact that the basement conglomerate did not necessarily indicate the base of the Carboniferous Limestone in any but a very local sense, and that these beds were the true equivalents of beds fairly high in the sequence elsewhere. His carefully detailed work and estimates of thicknesses have been of great help to us, and with most of his palæontological work we are in accord. A very serious error was made by Mr. Walker (Proc. Chester Soc. Nat. Sci., p. 9, 1878) in referring to the Holywell shales as the equivalent of the Lower Coal-measures of Lancashire, a mistake unfortunately adopted by the Survey, who state on p. 62 of the Memoir (op. cit. sup.):—"The Holywell shales, which run through the country and form a convenient base for the Lower Coal-measures, resemble some black shales, with bands or nodules of argillaceous limestone, which occur in the Lower Coal-measures of Lancashire, and contain a similar fauna, composed chiefly of *Posidonomya*, *Aviculopecten*, *Goniatites*, *Bellerophon*, coprolites of fish and plant remains." The absence of specific determinations renders this argument of very little value. Unfortunately for their point of view, *Posidonomya* (*Becheri*) does not occur in the Coal-measures. The *Goniatites* are Lower Pendleside forms, and the plants are not Coal-measure species.

Moreover, the Holywell shales are below the Gwespyr Sandstone, which is the equivalent in North Wales of the Millstone Grit. The thickness of this sandstone, about 300 feet, should have opened the eyes of anyone who knew the Lower Coal-measures of Lancashire or the Midlands, where a sandstone at all approaching that thickness is unknown. Moreover, Morton shows that the Gwespyr Sandstone has a matrix of decomposed felspar similar to the 1st or Roaches Grit of North Staffordshire. As far as we know, felspar is not present in this manner in any known Coal-measure sandstone. The mistaken correlation ought not to have occurred, on purely

lithological grounds. Nowhere in the Coal-measures of the Midlands or Lancashire does 1,000 feet of barren measures occur in the Lower Coal-measures free from workable coal-seams; the mistake would have been impossible if adequate study had been made of the fossils. Apparently the correlation was made simply on fossil evidence, but it does not appear that any steps were taken to officially check the accuracy of the views propounded. In "The History of the Parishes of Whiteford and Holywell" (1796), Thomas Pennant gives very clearly the relation of these shales to the limestone in this district: "The Holywell level was begun in 1774 . . . the entrance into the work (was) in Coed Cae Dentir, a field belonging to Sir Pyers (Mostyn) on the north side of a small dingle opening into the road opposite to the great cotton factory . . . The first forty yards . . . was arched with stone . . . when the arch ceased the roof was the natural rock of that species called shale . . . After passing in the shaley stratum about two hundred and twenty-six yards we find it is succeeded by that of Chert, at which spot the level enters my ground in the field called Coed Cae Norfa. There the height to the surface is eighteen yards. . . . The Chert continues to a little beyond the turnpike road, when we again enter the land of Sir Pyers Mostyn in a field called Brocknallt, where it stops. Hitherto the level has preserved a strait course, but in this field (where the lime-stone stratum begins) it turns and is continued to the end of the present working about five hundred yards" (pp. 249–250).

An excellent bibliography on the Geology of Denbighshire and Flintshire is to be found in the Memoir of the Geological Survey, "The Geology of the Coasts adjoining Rhyl, Abergele, and Colwyn," 1885, drawn up by Mr. W. Whitaker, and only slight additions are necessary.

1885. A. Strahan, "The Geology of the Coasts adjoining Rhyl, Abergele, and Colwyn": Mem. Geol. Surv.

1886. G. H. Morton, "Carboniferous Limestone and Cefn y Fedw Sandstone of Flintshire": Proc. Liverpool Geol. Soc., reprint in vol. i, pp. 1–78.

1887. —— "The Microscopic Characters of the Cefn y Fedw Sandstone of Denbighshire and Flintshire": Proc. Liverpool Geol. Soc., vol. v, pp. 271–280.

—— "Note on Carboniferous Limestone Fishes of North Wales": ibid., vol. v.

—— "On the Discovery of Sponge Spicules in the Chert Beds of Flintshire": Proc. Liverpool Biological Soc., vol. i, p. 69.

—— "Carboniferous Limestone of North Flintshire": Geol. Mag., Dec. III, Vol. IV, p. 120.

1889. R. Kidston, "On some Fossil Plants from Teilia Quarry": Trans. Roy. Soc. Edin., vol. xxxv, p. 419.

1890. A. Strahan & C. E. De Rance, "The Geology of the Neighbourhoods of Flint, Mold, and Ruthin": Mem. Geol. Surv.

G. H. Morton, "The Geology of the Country round Liverpool, including the North of Flintshire," pp. 287.

1897. —— "The Range of Species in the Carboniferous Limestone of North Wales": Geol. Mag., Dec. IV, Vol. IV, p. 132.

1897–8. —— "The Carboniferous Limestone of the Vale of Clwyd": Proc. Liverpool Geol. Soc.

1901. —— "The Carboniferous Limestone of Anglesey": ibid.

3. Description of the most important Sections.

For the sake of clearness, the exposures of the Carboniferous Limestone have been described according to their topographical arrangement rather than in their geological sequence. In this way, where several fossil horizons occur at any one locality, they have all been taken together as making up one section; the correlation of the individual horizons is dealt with in a later portion of this paper. It has, however, been found possible to treat the exposures in the Pendleside Series in their geological sequence, because of the accidental fact of each section being limited to one zone, which has enabled us to do this without involving any repetition or complicating the description as between horizon and locality.

Owing to the difficulty, in this sparsely populated district, in indicating localities with sufficient precision by reference to topographical names (which, by the way, are often subject to alteration), we have frequently resorted to their definition in terms of latitude and longitude, as marked off on the "1 inch Ordnance Maps," believing that this is the only way (unless personally conducted) in which other field geologists can in many instances locate the collecting-ground with tolerable certainty.

(*a*) *Carboniferous Limestone.*

(i) The romantic coast scenery in the neighbourhood of Llandulas is due to the irregular weathering of the Carboniferous Limestone forming the hills. The dip of the beds northwards to the sea may be beautifully seen in the series of long, parallel scars on both sides of the valley of the River Dulas, which has cut its way through the thick limestones. Ffernant Dingle was visited by us, but we have nothing to add to its description by Mr. A. Strahan, F.R.S., in the Geological Memoir of that district. At Llandulas, in a quarry by the roadside at the foot of Cefn hill (lat. 53° 19′ 5″ N., long. 3° 37′ 50″ W.), one of the limestones is characterised by the abundance of *Daviesiella Llangollensis* (Dav.). A little higher in the series another limestone bed contained great numbers of *Seminula* aff. *ficoidea*, Vaughan. On the south side of the hill, and south of the scattered village of Llysvaen (lat. 53° 16′ 20″ N., long. 3° 38′ 40″ W.), almost level with the road, a *Productus* Limestone may be seen, containing—

Productus aff. *Cora* (mut. D_1), Vaughan.
P. aff. *Cora* (mut. S_2), Vaughan.
P. hemisphericus, approaching in some characters *P. Cora*.
P. hemisphericus, Phill.

Following the same road further to the west, towards Bwlch-y-gwynt, a rather sandy limestone, with quartz-nodules, occurs somewhat higher in the series, with—

Cyathophyllum Murchisoni, E. & H. (Very common.)
Koninckophyllid—*Cyathophyllum*.
Lithostrotion aff. *Martini*, E. & H.
Syringopora cf. *distans*, Fischer.
Chonetes papilionacea, Phill. (Common.)

Above the preceding horizon is a very pure white limestone, containing—

Chonetes papilionacea, Phill. (Very common.)
Euomphalus pentangulatus, Sow. (Common.)

(ii) On the east side of the Vale of Clwydd, near the western base of Moel Hiraddug, at a quarry between Pentre-cwm and Pentre-bach, the so-called 'basement beds' (of the Geological Survey) are exposed, which here consist of alternating limestones and soft calcareous sandstones. The following list was obtained:—

Zaphrentis-like Coral.
Athyris expansa, Phill.
Chonetes papilionacea, Phill. (Convex form.)
Cliothyris glabristria (Phill.).
Productus sp.
Seminula aff. *ficoidea*, Vaughan. (Very common in one bed.)
Spirifer sp.
Archæosigillaria Vanuxemi (Göpp.).
Other plant-remains with *Spirorbis* attached.

The importance of this section lies in the abundance of *Seminula ficoidea*, which fixes the horizon in the series. The discovery of *Archæosigillaria Vanuxemi*, which was fairly common in the plant-bed, is of more than ordinary interest, since it has only been recorded hitherto "from the lower beds of the Mountain Limestone in the neighbourhood of Shap Toll-Bar, Westmoreland,"[1] and in that instance the horizon and locality are both somewhat vague; we are now able to give these particulars for the new find with precision.

(iii) In the next quarry, nearer to Dyserth, and 10 feet above the very thick bed of white limestone seen in its southern end, we collected—

Dibunophyllum sp.
Athyris expansa, Phill.
Chonetes papilionacea, Phill.
Spirifer. (With few thick and deep angular ribs.)
Euomphalus sp.
Fucoid (?).

(iv) Beds, higher in the series than the preceding, are exposed in a large quarry at Dyserth, bordering the south side of the Newmarket road, and in those constituting the floor of the quarry we obtained—

Cyathophyllum Murchisoni, E. & H.
Dibunophyllum sp.
Chonetes papilionacea, Phill.
C. papilionacea, Phill. (Convex variety.)
Productus hemisphericus, J. Sow.
Martinia glabra (Mart.).

(v) A smaller quarry is being worked near Meliden (lat. 53° 18′ 50″ N., long. 3° 24′ 30″ W.), where the beds may be observed dipping north at 50°. On account of the high dip comparatively few beds are exposed, but these are very fossiliferous, as may be supposed from an inspection of the following list:—

[1] R. Kidston: Trans. Nat. Hist. Soc. Glasgow (1899), p. 40.

Amplexus sp.
Densiphyllum sp.
Camarotoechia pleurodon (Phill.).
Diclasma hastata (Sow.).
Martinia glabra (Mart.).
Productus aculeatus (Mart.).
P. Cora, D'Orb.
P. elegans.
P. fimbriatus, Sow.
P. giganteus (Mart.).
P. hemisphericus, J. Sow.
P. latissimus, J. Sow.
P. Martini.
P. plicatilis, Sow.
P. punctatus (Mart.). (Common.)
P. scabriculus (Mart.).
P. semireticulatus (Mart.).
P. spinulosus, Sow.
P. striatus, Fischer.
P. undatus, Defrance.
Pugnax pugnus (Mart.).
Reticularia lineata (Mart.).
Rhynchonella angulata, Linn.
Bisulcate—*Spirifer* (homœomorphic with *S. clathratus*).
Spirifer bisulcatus, Sow.
S. planicostata, M'Coy.
S. pinguis (?), Sow.
S. striatus (Mart.). (Very large.)
Aviculopecten fimbriatus (Phill.).
Conocardium aliforme (Sow.).
Edmondia M'Coyi, Hind.
Myalina or *Posidoniella*.
Parallelodon obtusus (Phill.).
Pinna flabelliformis (Mart.).
P. mutica, M'Coy.
Posidoniella vetusta (Sow.).
Protoschizodus æquilateralis (M'Coy).
Pseudamusium ciliptieum (Phill.).
Pterinopecten semicircularis, M'Coy.
Sanguinolites striato-lamellosus, De Kon.
Solenomya sp.
Syncyclonema carboniferum, Hind.
Cyrtoceras sp.
Glyphioceras crenistria (Phill.).
Orthoceras. (Large.)
Euomphalus sp.
Straparollus Dionysii, Montf.
Capulus or *Pileopsis*.
Naticopsis sp.
Phillipsia sp.
Petalodont tooth.

(vi) Along the main road further to the east, in the large quarry at the base of the hill, nearly into the southern end of Prestatyn, the limestone beds are very dark in colour, and are observed dipping to the east. Those forming the floor of the quarry are rather disappointing to the collector. The only forms we observed were—

Productus longispinus, Sow.
Martinia glabra, Mart.
Campophyllum Derbiense.
Zaphrentis aff. *Enniskilleni*, Vaughan.

A little higher in the same quarry we found—

Fenestella sp.
Camarotoechia pleurodon (Phill.).
Chonetes papilionacea, Phill.
Productus, sp. nov.

And about 8 feet higher still we noted a *Productus*-bed with—

Orthotetes crenistria (Phill.).
Productus, sp. nov.
P. fimbriatus, Sow.

(vii) In taking the road from Prestatyn to Gwaenysgor, at the first rise of the hill there is an old quarry now being filled up with building débris, where the following list was obtained:—

Fenestella sp.
Chætetes tumidus.
Dibunophyllum sp.
Lithostrotion sp.
Crinoids.
Archæocidaris. (Spine.)
Athyris planosulcata, Phill.
Orthotetes crenistria (Phill.).
Productus costatus, J. Sow.
P. plicatilis, Sow.
P. punctatus (Mart.).
Productus. (Elegantly reticulated.)
P. striatus, Fischer.
Spiriferina cristata, Schloth.
Trilobite.

Near the top of the section is a Crinoid-bed, with *Michelinia tenuisepta* (?): about 6 feet higher up the hill is a compact limestone, with chert nodules, containing—

Lithostrotion Martini, E. & H.
Syringopora sp.
Archæocidaris. (Spine.)
Palæechinus. (Plates.)
Productus giganteus, Mart.
Spirifer sp.
Euomphalus sp.

(viii) At the top of the hill near Gwaenysgor (lat. 53° 19′ 25″ N., long. 3° 23′ 20″ W.) there is a disused quarry, containing a lime-kiln, where the beds are found dipping north-east at 15°, which yielded the following fauna:—

Dibunophyllum sp. (Not common.)
Lithostrotion Martini, E. & H.
Zaphrentid Coral.
Crinoids.
Athyris planosulcata, Phill.
Productus aculeatus (Mart.).
P., sp. nov.
P. giganteus (Mart.). (Rather rare.)
Camarotœchia pleurodon (Phill.).
Productus giganteus (Mart.) (var. *Edelburgensis*), Phill.
P. hemisphericus, J. Sow.
P. margaritaceus, Phill.
P. punctatus (Mart.).
P. semireticularis (Mart.).
Pugnax acuminata (Mart.).
Schizophoria resupinata (Mart.).
Spirifer duplicicostatus (?). (Broad-ribbed form with angular ribs.)
S. striatus (Mart.).
Spiriferina cristata, Schloth.
Pleurotomaria sp.

(ix) In a small quarry on the left-hand side of the road leading from Gwaenysgor to Teilia Farm we collected—

Cyathaxonia.
Crinoids.
Productus giganteus (Mart.).
Pugnax pugnus (Mart.).
Spirifer aff. *bisulcatus*, Sow. (Characteristic of D_2 zone in Bristol area.)
Martinia glabra (Mart.).
Spirifer planicostatus (variant).[1]
S. sp. (Angular-ribbed form.)

(x) An exposure at the foot of the hill (on the 200 feet contour-line), opposite the Nant Hotel, Prestatyn, and east of the road from that place to Gwaenysgor, yielded—

? *Cyathaxonia* sp.
Dibunophyllum sp.
Chonetes papilionacea, Phill.
Productus fimbriatus, Sow.
P. semireticulata-longispinus.
Martinia glabra (Mart.).

A little further to the south-east, in the wood, may be seen the upper beds of limestone, with *Productus giganteus* (Mart.) fairly common.

(xi) In a quarry at Pentre, near Gronant (see *infra*, Part II, paragraph xxxv), there is a magnificent section in the chert beds, of which there is not less than 70 feet exposed. They are largely worked for 'setts,' used in the grinding of china-stone, etc., for the manufacture of pottery. In these cherts we observed—

Productus longispinus, Sow.
P. punctatus (Mart.).
P. sp. (Very spinose.)

(xii) In an old, disused limestone quarry north of Axton Mine we noted—

Fenestella.
Athyris planosulcata, Phill.
Diclasma hastata (Sow.).
Martinia glabra (Mart.).
Productus giganteus (Mart.).
P. elegans.
P. punctatus (Mart.).
P. semireticulatus (Mart.).
Schizophoria resupinata (Mart.).
Spirifer sp. (With broad, angular folds.)

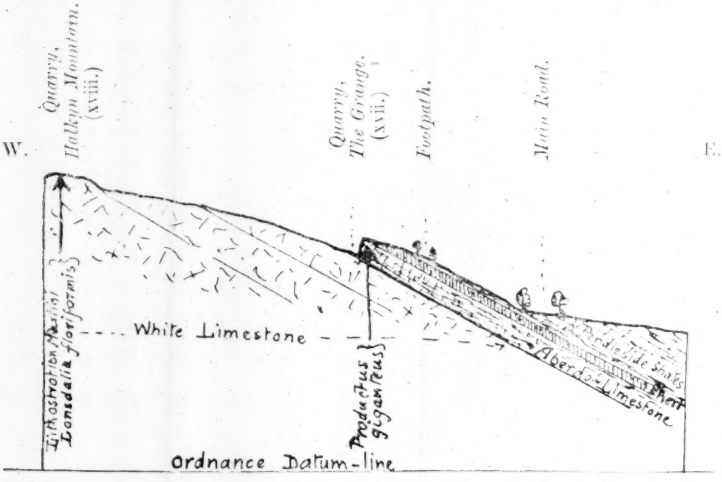
This, probably, is the quarry referred to by G. H. Morton.[2]

[1] A similar variety occurs at Curkeen according to Dr. A. Vaughan.
[2] G. H. Morton: Proc. Liverpool Geol. Soc., vol. v, p. 181.

(xiii) A limestone quarry in the next field to the Axton Mine is being worked at the present time, and from it we obtained—

Cyathophyllum Murchisoni, E. & H.
Monticuliporoid Coral.
Fenestella sp.
Dielasma hastata (Sow.).
Productus aculeatus (Mart.).
P. fimbriatus, Sow.
P. giganteus (Mart.).
P. punctatus (Mart.).
P. scabriculus (Mart.).
P. semireticulatus (Mart.).
Rhynchonella sp.
Martinia glabra.
Spirifer grandicostatus, M'Coy.
S. striatus (Mart.).
Bellerophon sp.

(xiv) At Trelogan the uppermost beds of the Carboniferous Limestone have been very extensively quarried, and they are locally known as 'Aberdo' limestone—this appellation being reserved for limestones of exceptional value for the production of hydraulic cement. In one of the quarries at this place we are fortunately able



Horizontals, about 5⅓ inches to a mile; verticals, 450 feet to an inch.

FIG. 1.—Diagram-Section Eastern flank of Halkyn Mountain.

to see the position of the limestones in conjunction with the cherts. A photograph of the section is shown in Plate XXI, where the erratic pinching-out of the bands of black limestone may be observed. The beds dip N.N.E. at 15°, forming the dip slope of the hill. The succession is:—

Cherts	...	...	20 feet +
Limestone and shales		...	35 feet +

The strata are singularly devoid of fossils, although several gigantei *Produeti*, *P. costatus*, and *Campophyllum Murchisoni* were seen in the bed of limestone immediately below the chert.

(xv) A lower horizon is exposed at the surface at Garreg, where a large quarry in white limestone is being worked at the present time (lat. 53° 17′ 45″ N., long. 3° 18′ 10″ W.). The uppermost bed, 12 feet thick, is of a detrital character, consisting mainly of crinoids.

Trelogan Quarry, Halkyn Mountain.

In the bed forming the floor of the quarry the following fossils were obtained :—

Dibunophyllum sp.
Crinoids.
Productus giganteus (Mart.).
P. hemisphericus, J. Sow.
Reticularia lineata (Mart.).
? *Spirifer rotundatus*, Sow.

(xvi) On the eastern flank of Halkyn Mountain the upper beds have been worked in a series of quarries from Trelogan to Pentre Halkyn for 'Aberdo' limestone. The individual beds are never thick—2 feet or 2 ft. 6 in. being the maximum—and usually they are separated by thin shale-bands. As we go north the shale-partings constitute an increasing proportion of the sections, as may be seen by comparing the photographs, Plates XXI and XXII and Fig. 1. One of the quarries opened up in these beds was examined at Gorsedd (lat. 53° 16′ 50″ N., long. 3° 16′ 10″ W.), where the shales and limestones were all highly fossiliferous. Undoubtedly the most striking form, by reason of its numbers and the development of its individuals, was *Productus giganteus* (Mart.). The full list from this quarry was :—

Athyris cf. *planosulcata*, Phill.
Chonetes sp.
Lingula mytiloides, Sow.
Orbiculoidea nitida (Phill.).
Orthotetes crenistria (Phill.).
Productus giganteus (Mart.). (Very common.)
P. semireticulatus (Mart.).
P. Youngianus, Dav.
Reticularia lineata (Mart.).
Rhipidomella Michelini (L'Eveillé).
Schizophoria resupinata (Mart.).
Spirifer sp.
Phillipsia sp.

(xvii) About one and a half miles further south, on the road to Holywell, a very large quarry has worked beds at the same horizon and of the same quality (i.e. 'Aberdo' stone) at the Grange, Holloway (lat. 53° 16′ 30″ N., long. 3° 14′ 25″ W.). At this quarry we get an uninterrupted sequence from the limestone, through the cherts, into the lowest shales and thin black limestones of the Pendleside Series. Overlying the 'Aberdo' beds there is a white limestone, almost 7 feet thick, the lower portion of which is cherty and the upper portion is crinoidal; resting upon the latter is about 6 feet of lenticular dark limestone and thin shales, and these pass upwards into the cherts, which at this locality are thinly bedded, and as a series are attenuated. The cherts dip eastwards at 22° (Pl. XXI) In the limestones and intervening shales we collected—

Lithostrotion irregulare.
Amplexi-zaphrentis θ, Vaughan MS.
Caniniad—*Dibunophyllum*, Vaughan MS.
Dibunophyllum sp.
Favosites parasitica (Phill.).
Fenestella.
Athyris planosulcata, Phill.
Chonetes Buchiana, De Kon.
C. Laguessiana, De Kon.
C. papilionacea, Phill.
Orthotetes crenistria (Phill.).
Productus corrugatus,[1] Phill.
P. giganteus (Mart.). (Common.)
P. longispinus, Sow.
P. scabriculus (Mart.).
P. semireticulatus (Mart.).
Reticularia lineata (Mart.).
Rhipidomella Michelini (L'Eveillé).
Spirifer, var. of *S. bisulcatus*, Sow.
S. ovalis, Phill.
S. planicostatus, M'Coy (not *S. crassus*, De Kon.).
Spiriferina sp.
Syringothyris cuspidata (Mart.).
Aviculopecten dissimilis (Flem.).
Orthoceras sp.
Phillipsia sp.
Petalodus acuminatus (Agass.).

[1] This form is characteristic of the Upper *Dibunophyllum* zone.

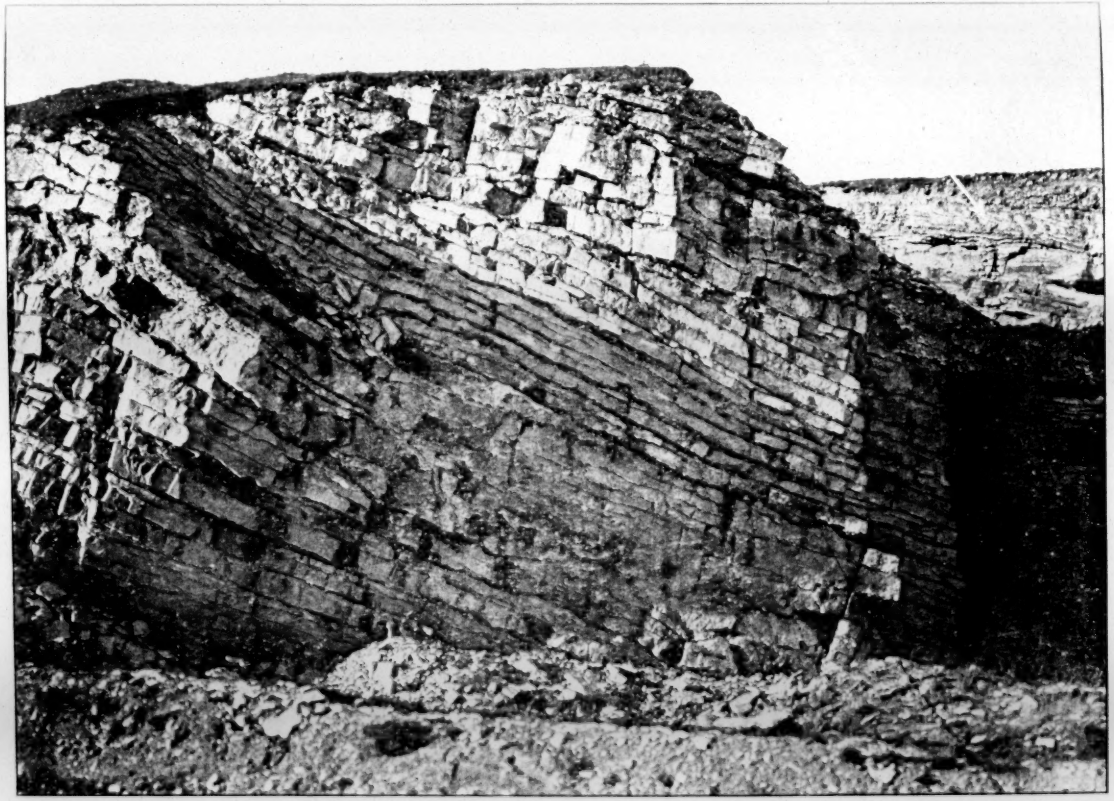
(xviii) Following the old wagon-way about 600 yards up the dip-slope of the hill from the preceding section, we reach a quarry in the white limestone, at the top of which is a *Productus*-bed about 10 feet thick, containing

Lithostrotion Martini, E. & H.
Lonsdaleia floriformis (Flem.).
Syringopora sp.
Crinoids.
Productus giganteus (Mart.).
P. hemisphericus (Mart.).
P. scabriculo-costatus, Vaughan MS.

(xix) South of Holywell, along the eastern margin of Holywell Common, a large number of quarries are being worked in the chert-beds, which here also overlie limestones of the 'Aberdo' quality. Some of the chert-bands contain numerous crinoidal casts. An old quarry near Pentre Halkyn, where the cherts were to a large extent desilicified, yielded the following fauna:—

Crinoids.
Dielasma hastata (Sow.).
D. ficus.
Orthotetes crenistria (Phill.).
Productus longispinus, Sow.
P. scabriculus (Mart.).
P. rugatus.
Spiriferina hiplicata, Dav.
Syringothyris laminosa (M'Coy).
Ostracods.
Deltoptychius sp.
Psephodus magnus (M'Coy).
A new Crustacean.

(xx) Further to the east, near Waenbrodlas, the 'Aberdo' limestones are being worked by most extensive quarries, which are in many respects the most remarkable in the county of Flint. These limestones occur at the same horizon as those at Holloway, Gorsedd, and Trelogan, already described. The photograph (Pl. XXII) shows part of the face of the Waenbrodlas quarry, which presents physical features of some interest. A peculiar case of false bedding is here most clearly seen, where the edges of one set of thin limestones appear to have been almost planed off in a flat surface before the deposition of another bed of limestone of singularly uniform thickness and persistency. In the uppermost beds of the same quarry, and only partially represented on the right-hand side of Pl. XXII, a similar phenomenon may again be observed; in the latter instance the rate of cutting out of the lower set of limestones is 1 in 13. From the persistent parallelism of the upper and lower surfaces of the individual beds of limestone we infer that these two interruptions in the deposition of the strata were not of the nature of current-bedding, but really represent slight unconformities as a result of earth-movement at the time they were laid down, and though here they appear inconsiderable, it is possible that the movement at this period produced more striking results in other localities. In this connection we may remember that the 'Aberdo' variety of limestone (which is the kind worked in this quarry) is of very local distribution and of very erratic occurrence. The proportion of shale to limestone is extremely variable, increasing from Waenbrodlas to Trelogan, whilst further to the south and west the 'Aberdo' beds are absent altogether. Contemporaneous earth-movement is an easy explanation of this irregularity of deposition, and the section represented in Pl. XXII may offer some direct evidence in support of this view.



Waenbrodlas Quarry, Halkyn Mountain.

The actual top of the quarry, where the beds were much weathered, was characterised by the presence of corals of diagnostic importance, viz.:—

Cyathaxonia aff. *Rushiana*, Vaughan.
Lithostrotion irregulare (Phill.).
Lonsdaleia floriformis (Flem.).
L. rugosa, M'Coy.

Here again, in even greater numbers than at Gorsedd and Holloway, were *Producti* of the largest size. The full list from this quarry is as follows:—

Amplexi-zaphrentis, Vaughan MS.
Callophyllum θ, Vaughan.
Campophyllum cf. *Murchisoni*, E. & H.
Clisiophyllum aff. *Cuvieriensis*, n.sp., Vaughan.
Cyathaxonia aff. *Rushiana*, Vaughan.
Dibunophyllum sp.
Lithostrotion irregulare (Phill.).
L. Portlocki (Bronn).
Lonsdaleia floriformis, Lonsd.
L. rugosa, M'Coy.
Michelinia sp.
Archæocidaris sp.
Palæechinus sp.
Pentacrinus sp.
Glauconome sp.
Athyris expansa, Phill.
A. (*Actinoconchus*) *planosulcata*, Phill. (Wetton form.)
A. sp.
Camarophoria[1] cf. *crumena* (Mart.).
Chonetes cf. *Laguessiana*.
Martinia glabra (Mart.).
Orthotetes crenistria (Phill.).
Productus giganteus (Mart.). (Very abundant.)
P. giganteus, var. *Edelburgensis*.
P. latissimus, J. Sow.
P. longispinus, Sow. (Common.)
P. punctatus (Mart.).
P. scabriculo-costatus, Vaughan MS.
P. semireticulatus (Mart.).
P. sinuatus, De Kon.
P. Youngianus, Dav.
Reticularia lineata (Mart.).
Spirifer bisulcatus.
S. cf. *duplicicostatus*, Phill.
S. integricostatus, Phill.
S. cf. *pinguis*,[1] Sow.
S. planicostatus, M'Coy.
Aviculopecten dissimilis (Flem.).
Pseudamusium ellipticum (Phill.).
Bellerophon sp.
Serpulites membranacea, M'Coy.
Pachodus sp.
Psammodus sp.
Psephodus magnus (M'Coy).

(xxi) The most important sections of Carboniferous Limestone in the district around Mold are confined to the hilly range extending from Hendre to near Llanferres. At the former place there are two quarries in the limestone at the same horizon. Since that on the north side of the road exhibits more of a sequence, its individual beds were more carefully worked. In the following section the particulars given by Mr. A. Strahan, F.R.S., in the Geological Memoir of Flint, Mold, and Ruthin, p. 39, are adopted:—

7.	Sandstone	27 feet.
6.	Shale	48 ,,
5.	Line of grit	,,
4.	Massive Coralline Limestone ...	12 ,,
3.	Thin-bedded Coralline Limestone ...	55 ,,
2.	Limestone and shale	17 ,,
1.	Limestone	70 ,,

No. 1 (limestone) contains *Cyathophyllum regium*, Phill.

No. 2 (limestone and shale) contains—

Fistulipora aff. *incrustans*, N. & T. (Vaughan).
Athyris planosulcata, Phill.
Productus longispinus, Sow.
Ichthidiomella Michelini (L'Eveillé).
Seminula ambigua (Sow.).
Spirifer cf. *duplicicostatus*, Phill.
Spiriferina bipticata, Dav.
Encrinus sp.

[1] Upper *Dibunophyllum* zone form.

No. 3 (thin-bedded Coralline Limestone) contains—

Cyathophyllum regium, Phill.
Dibunophyllum (probably) *Corwenense*, n.sp. (large).
Koninckophyllum magnificum, N. & T.
Lithostrotion irregulare (Phill.).
L. junceum (Flem.).
Lonsdaleia floriformis (Flem.).
Schizophoria resupinata (Mart.).

No. 4 (massive Coralline Limestone) contains—

Chætetes sp.
Lithostrotion cf. *ensifer*, E. & H.
L. junceum (Flem.).
L. Portlocki (Bronn).
Amplexi-zaphrentis sp.
Phillipsastræa radiata, E. & H.
Schizophoria resupinata (Mart.).

No. 6 (shale) contains—

Campophyllum sp.
Cyathophyllum Murchisoni, E. & H.
Dibunophyllum θ–ψ, Vaughan.

At the smaller quarry at Hendre we collected from the limestone, corresponding to No. 1 of the preceding section:

Lithostrotion basaltiforme (Phill.).
Productus Cora, D'Orb.

And from the overlying limestone and shale—

Dibunophyllum sp.
Lithostrotion irregulare (Phill.).
Crinoids.
Athyris planosulcata, Phill.
Camarotœchia pleurodon (Phill.).
Chonetes Laguessiana, De Kon.
Productus latissimus, J. Sow.
P. longispinus, Sow. (Common.)
P. punctatus (Mart.).
P. semireticulatus (Mart.).
Rhipidomella Michelini (L'Eveillé).
Schizophoria resupinata (Mart.). (Common.)
Seminula ambigua (Sow.).
Spirifer triangularis (Mart.).
Spiriferina cristata, Schloth.
Allorisma-like shell.

(xxii) The exposure at Gwernymyndd is an important one, and although it differs somewhat in its lithological character from those seen elsewhere, its palæontological features can easily be identified with those of other localities.

The following is the sequence of the upper strata at this place:

6. Grit and sandstone.
5. Encrinital and arenaceous limestone.
4. Shale.
3. Chert band.
2. Quartz-grit and sandstone.
1. Encrinital limestone.

In the grit and sandstone at the top of the section, which was largely disintegrated, we found many fossils—the number of fish-teeth being extraordinary. The list obtained was—

Lithostrotion irregulare (Phill.).
Lonsdaleia rugosa, M'Coy.
Crinoids.
Orthotetes crenistria (Phill.).
Productus longispinus, Sow.
Spirifer sp.
Ctenoptychius lobatus (R. Eth., jun.).
Cochliodont tooth.
Psaciladus sp.

The upper portion of the limestone (No. 5) below the grit was 'rubbly' in character, and contained *Productus giganteus* in fair abundance; in the lower portion we collected—

Amplexi-zaphrentis, Vaughan MS.
Dibunophyllum sp.
Fistulipora aff. *incrustans*, N. & T. (Vaughan).
Crinoids.
Athyris planosulcata, Phill.
Chonetes Laguessiana, De Kon.
Martinia glabra (Mart.).
Productus punctatus (Mart.).
P. pustulosus, Phill.
Spirifer bisulcatus, Sow. (Common.)

No. 4 (shale) was highly fossiliferous, and contained—

Athyris planosulcata, Phill.
Lingula mytiloides, Sow. (elongate sp.).
Martinia glabra (Mart.).
Productus cf. *semireticulatus* (Mart.).
Allorisma variabilis (?).
Aviculopecten dissimilis (Flem.).
Lithodomus lingualis (Phill.).
Nuculana attenuata (Flem.).
Parallelodon sp.
Posidoniella elongata (Phill.).
Solenomya sp.
Streptoceras bisulcata.
Straparollus sp.

No. 1 (encrinital limestone) yielded—

Amplexi-zaphrentis φ, Vaughan MS. (= *Z. Bowerbanki*, Thomp.).
Chonetes papilionacea, Phill.
Spirifer bisulcatus, Sow. (Common.)
S. grandicostatus.
S. integricostatus, Phill.
S. cf. *triangularis* (Mart.). (Common.)
S. trigonalis (Mart.), D'Orb. (Common.)

(xxiii) Further west, at a quarry in white limestone, which is worked in the wood near the summit of the hill east of the Loggerheads Inn, the following list was obtained:—

Dibunophyllum sp.
Syringopora cf. *distans*, Fischer. (Fairly common.)
Athyris expansa, Phill.
Dielasma hastata (Sow.).
Martinia glabra (Mart.).
Productus Cora, D'Orb.
P. giganteus (Mart.). (Not rare.)
P. hemisphericus. (Common.)

(xxiv) Crossing the River Alyn to the east, near Llanferres, we have a fine escarpment of the Carboniferous Limestone from the 700 feet contour-line to the 1,000 feet contour at Pant-du. Up this gorge the beds can be seen to have a regular dip south-east at 17°. At the bottom of the pass, near the river, the beds contain *Cyathophyllum Murchisoni*, E. & H., in abundance, and associated with it *Chonetes papilionacea*, Phill., which is a large, convex, fine-ribbed form, common at Cauldon Low, North Staffordshire. In addition we collected—

Alveolites septosa (Flem.).
Dibunophyllum sp.
Lithostrotion Martini, E. & H.
Syringopora cf. *distans*, Fischer.
Productus fimbriatus, Sow.
P. hemisphericus, J. Sow.
Spiriferina cristata, Schloth.

(xxv) Above Pot Holes the beds of limestone are thinner and often cherty; here we found—

Campophyllum sp.
Lithostrotion irregulare (Phill.). (Large variety, very common.)
L. junceum (Flem.).
L. Martini, E. & H.
L. Portlocki (Bronn).
Syringopora sp.
Productus giganteus (Mart.). (Abundant.)

And noted also beds of silicified *Productus giganteus* (Mart.) and crinoids similar to those occurring at Waenbrodlas.

(xxvi) Limestones higher in the series may be seen in the line of small quarries on the east side of the road, and parallel to it, at Gwyndy, where we obtained—

Amplexi-zaphrentis φ, Vaughan MS.
Productus longispinus, Sow.
P. punctatus (Mart.).
P. scabriculus (Mart.).
Spirifer bisulcatus, Sow.

(xxvii) In a disused quarry about 600 yards further north (lat. 53° 8′ 0″ N., long. 3° 10′ 52″ W.) the limestones and shales are remarkably fossiliferous, and yielded the following list:—

Amplexi-zaphrentis ϕ, Vaughan MS.
Campophyllum aff. *Murchisoni*, E. & H.
Cyathaxonia (?) sp.
Densiphyllum sp.
Dibunophyllum sp.
Cyclophyllum pachyendothecum, Thomp.
Athyris planosulcatus, Phill.
Chonetes Laguessiana, De Kon.
C. papilionacea, Phill.
Productus giganteus (Mart.).
P. longispinus, Sow.
P. pustulosus, Phill.
Schizophoria resupinata (Mart.).
Seminula ambigua (Sow.).
Spirifer bisulcatus, Sow. (Very abundant.)
S. cf. *triangularis* (Mart.). (Very abundant.)
S. trigonalis (Mart.), D'Orb. (Very abundant.)

(*To be continued in our next Number.*)

II.—The Chalk Bluff at Trimingham.

By Professor T. G. Bonney, D.Sc., LL.D., F.R.S.

(With two Text-figures.)

MR. R. M. BRYDONE'S account of the masses of chalk exposed on the Norfolk coast near Trimingham,[1] published in this Magazine during the first three months of the present year, is a valuable record of facts revealed by the encroachments of the sea, but it raises questions of a general nature, on which I should at once have commented, had I not preferred to wait until I could again examine the sections. This was done in company with the Rev. E. Hill during Easter week, when we found that even since the middle of last October (the date of Mr. Brydone's latest photograph) the destruction had been considerable.[2]

The isolation of the more notable bluff[3] is now complete. Though a memorial of defeat, it rises from the shore like a Roman arch of triumph (Fig. 2), one pier of which is formed of chalk, the other of boulder-clay (the so-called Cromer 'till'), while the outlines of the second and third masses[4] have been modified, as indicated in the sketch-plan (Fig. 1).

As I have not found Mr. Brydone's paper very easy to follow, owing to its being somewhat discursive and crowded with minute palæontological details, the time of readers may be saved by briefly enumerating the points to which I take exception. These palæontological details I abstain from discussing because I think that even

[1] I have followed the spelling of the Survey Memoir and my copy of the Ordnance Map.

[2] It may facilitate references to mention that in our paper we refer to the chalk masses as eastern and western (another instance of inattention to the minutiæ of the literature of the subject) where Mr. Brydone and some earlier writers use southern and northern. Herein we followed our notes; for the trend of the coast is more nearly in the former direction. From Weymouth to Sheringham it is nearly west and east. From the latter place it runs about E. 10° S., beginning at Cromer to point rather more to the south, and for some distance on either side of the 'bluff' its general direction is from 30° to 35° S. of E., not running quite S.E. even beyond Mundesley.

[3] That marked A in the illustration accompanying our paper (Plate XXII) in the September number of this Magazine, 1905.

[4] C and E of the same Plate.

if admitted they do not substantiate his conclusions. So I leave them and the nomenclature of zones to experts like Messrs. Jukes-Browne[1] and A. W. Rowe, and restrict myself to such as bear on the question discussed in our former paper, which dealt almost exclusively with the so-called northern block or blocks near Trimingham.[2] Mr. Brydone maintains the most noted one to be the remnant of a sea-stack or buried cliff, adopting a modification of the view put forward by Mr. Jukes-Browne.[3] This stack or cliff was formed at the margin of a chalk upland which, presumably in early Pliocene times, occupied the place of the present sea; the one

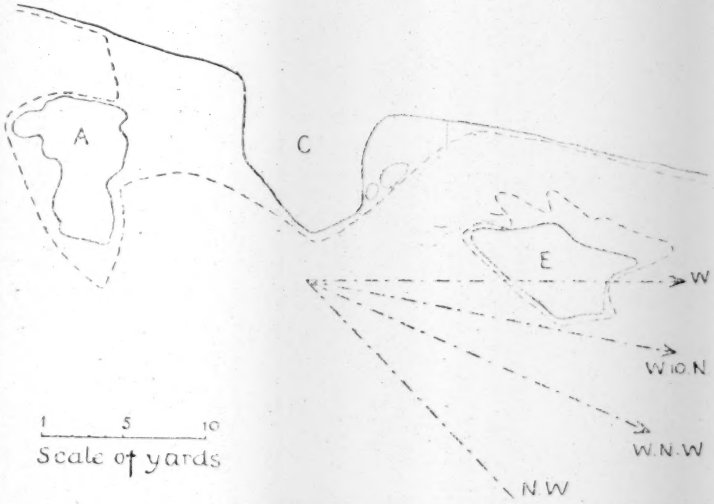


FIG. 1.—Sketch-plan (by Rev. E. Hill) of the "westerly chalk bluff" at Trimingham (see Plate XXII in the volume for last year).

The broken line indicates the boundary of chalk or clay in April, 1905; the continuous one that observed on almost the same day in the present year. A, E, C correspond with the masses bearing these letters on the above-named Plate, the first being the 'contorted' one, the condition of which at the latter date is shown in Fig. 2. The plan, Mr. Hill wishes me to say, does not pretend to minute accuracy.

which made it lying to the south-west and west. Mr. Brydone states that the uppermost part of the chalk (about two feet) visible at the headland differed from that below, lithologically in its grey colour, more crumbly condition, and apparently horizontal stratification, and palæontologically in several respects, notably the absence of *Ostrea lunata*; that this grey chalk formed an apparent connection with the chalk mass, then only recently disclosed (C), and, when

[1] This sentence was written in May; see GEOL. MAG., July, p. 335.

[2] The 'southern' chalk masses are mentioned only once in that paper, in a few lines at the end of p. 400 and beginning of p. 401. I shall again briefly refer to them in the present paper.

[3] Ann. Nat. Hist., sec. v, vol. vi, p. 305.

viewed from the more eastern side, seemed to be prolonged into a slab terminating in a kind of lobe.[1] The upper part of C and portions of its sloping more western face were also formed of the grey chalk, which Mr. Brydone found to be generally separated from the white chalk (in which *Ostrea lunata* is abundant) by a thin seam of 'fine grit' in which are scattered flint pebbles about the size of a potato, and which "sometimes swells out into a definite bed as much as two inches thick, containing small rolled pieces of Chalk."

This gravel Mr. Brydone assigns to Cretaceous times. He believes that late in that period earth-movements occurred which produced the flexures (attributed by Mr. Reid to the thrust of an ice-sheet), and that these were followed by denudation which removed part of the chalk and formed the gravelly seam, after which subsidence was renewed and the grey chalk deposited. The presence of water-worn flints in the chalk, as Mr. Brydone remarks, is practically unique, and if his view be correct it would throw "an important light on the time of consolidation of the flints, which must have taken place in this case almost simultaneously with the deposition of the Chalk in which they were formed" (p. 20). It does not, however, appear to occur to him that so unusual an occurrence requires exceptionally strong proof.[2]

The infilling of the 'arch' with clay and the apparent passage of the latter beneath the chalk in the masses C and E[3] receive from Mr. Brydone the following explanation (p. 77). At some date shortly before the formation of the glacial beds, the chalk must have been again raised and exposed to the erosive action of a sea lying to the south-west of the present coast, the waves of which formed caves in its cliffs, and these caves were filled by the first inflow of boulder-clay. The bottoms of them are probably well below the present beach-level,[4] so that we see only horizontal sections through the roofs and the upper surface of the infilling clay, which then, of course, seems as if it underlay the severed roof by natural deposition. The detached blocks of chalk visible in the cliff behind the 'bluff' "have clearly been carried up by a mass of clay from below, and represent parts of the roofs of these caves which were too weak to resist the upward pressure of the clay."

I now proceed to give a brief description of what we saw last April. The 'arch' (Fig. 2) was, more strictly speaking, a big window, the low 'sill' being formed of the usual boulder-clay, which exhibited a rather marked stratification as it approached the

[1] See Plate IX, No. 16, of Mr. Brydone's paper (p. 130). My sketch ended at the sudden rise of the clay, the left-hand one of the two (the oblong block of chalk beyond) being at that time hidden.

[2] The line of worn flints between the white chalk and the yellowish limestone of Maestricht to the south-west of that town is hardly a parallel.

[3] According to old diagrams the clay formerly underlay a corner of the chalk of which A is a remnant.

[4] If this view be correct, it is a little singular that the chalk should so often show up in this neighbourhood between tide-marks, still retaining in places a skin of boulder-clay.

chalk. The latter rock formed the seaward pier, and the curved bands of flints were distinctly visible on its more western and more eastern faces. On the former we saw, above the uppermost of these bands, a fairly distinct gritty streak (*f*), which was approximately on the level of the top of the 'arch' and was prolonged for some distance landwards. A mass of boulder-clay formed the landward pier, changing, in the right spandril of the arch, into a marly chalk. This was interrupted near the middle by a streak (*g*), averaging about two inches in thickness, which contained flint pebbles and looked like the 'washings' of boulder-clay. The eastern side of the 'arch' showed the masses of chalk and boulder-clay (the latter exhibiting stratification at a high angle), the rubbly grey chalk described by Mr. Brydone, and the two streaks just mentioned, the upper one

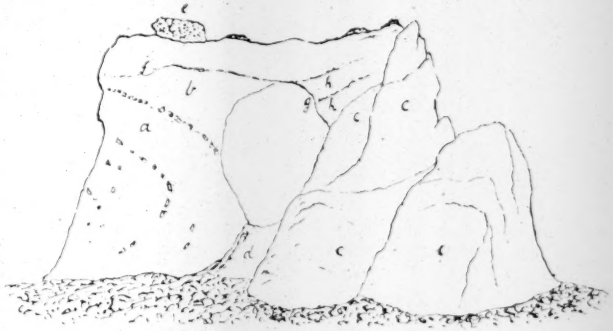


FIG. 2.—Remnant of Bluff near Trimingham, sketched from the Cromer side, April 18, 1906.

a. Chalk with flints.
b. Marly-looking chalk with some flints (probably remanié).
c. Boulder-clay.
d. Boulder-clay showing stratification.
e. Gravel, greatest thickness about 1 foot; little patches of it remain here and there to the right.
f. Gritty streak, generally distinct.
g. Streak, from 2 to 2½ inches thick, of clay with flint pebbles, looking like rearranged boulder-clay.
h. Marly chalk.

being apparently more marly at the seaward end and more gravelly at the other, and the lower one a gravel. Overlying the grey chalk (near the former end) was a patch of coarse gravel—perhaps a foot thick—remnants of which could be detected on the landward side. On the upper part of the sloping face of the second mass (C) we failed to discover any traces of the gritty or gravelly seam[1] between the grey and the white chalk (that containing *Ostrea lunata*), but a thin seam of fine gravel could be detected at the foot of the slope apparently overlain by the chalk (both grey and white) and overlying boulder-clay, a mass of which formed a kind of abutment,

[1] We attach no particular importance to its absence and do not dispute Mr. Brydone's observation.

rising to a height of a few inches from the shore-shingle and apparently supporting one or two outlying fragments of chalk. Boulder-clay, as shown in Mr. Mallet's photograph of 1905, underlay both the landward end of the mass C and the curved slab E.[1] That these two might be connected beneath the beach now seemed more probable than in 1905, but, if so, the mass must be strangely twisted, and the same would be true of the thin slab exposed in the cliff above.[2] In this case, however, the very great thickness of the well-bedded gravel underlying this slab on the more western side would be very difficult to explain, and we think it far more probable that the latter at any rate is a separate boulder.

In short, I cannot accept the principal points in Mr. Brydone's reading of this section—that any of these chalk masses are sea-stacks, or the gritty seam is a Cretaceous deposit, or the grey chalk is part of a mass *in situ*. If it be, its position at the top and bottom of the sloping face of the mass C is a great and by no means the only difficulty. Much of this grey chalk has the appearance of remanié material.[3] That it has not been derived from rock quite identical with the white chalk below I fully believe, for I think that at this place two or three boulders have been dropped so as to be once or twice in actual contact, as has happened in at least one instance between the two Runton Gaps. I have often seen chalk fallen from a cliff which, were it frozen, transported, and then buried where clay or grit was accumulating, would present just the appearance of this grey chalk in the places we have described. We must also not forget the possibility of grey chalk from the higher part of a cliff falling on the top of white chalk from the lower part, when the two might be frozen together and transported as one block. In fact, I consider these boulders, like those near the Sidestrand Hotel, one or two of which are still visible, to be of "quite local origin" (p. 16). I differ also from Mr. Brydone in supposing that, while by a singular chance the present sea-line so nearly corresponds with that in pre-Glacial time, a chalk upland lay on the northern and the sea itself on the southern side. Neither can I understand how the Mundesley well section drives "a final nail into the coffin of the erratic theory" (p. 125), seeing that I have always looked in this direction for the chalk cliffs from which the erratics were derived.[4]

The two chalk masses nearer Mundesley—the south bluff of previous writers—were not so well exposed, either on this or on the previous occasion, as at some of Mr. Brydone's visits; the attenuated

[1] This seemed to have been reduced in thickness since our last visit.

[2] See Mr. Brydone's photograph, Pl. V, Fig. 11.

[3] Mr. Brydone says this chalk cannot be remanié because delicate fossils in it are unbroken. But, as we can still see in blocks of chalk fallen from the cliffs, the exterior breaks up into fragments, the interior only cracking, so that the former may get mixed with clay or gravel and yet not be ground up, and the latter be only fissured.

[4] The drift hills inland from east of Mundesley to west of Sheringham are quite high enough to conceal a buried line of pre-Glacial cliffs. One would be glad if it could be ascertained whether the chalk, worked in old pits and now exposed on the new railway cutting between Cromer Station and Overstrand village, is *in situ* or only a very large erratic.

extension on the Mundesley side of the more eastern mass being only visible at one place, and thus like a separate boulder. We found no evidence (but that might have been due to unfavourable circumstances) in favour of the two forming part of a single mass, traversed by a fault, and thought them, as on previous occasions, more probably both separate and erratics.

In conclusion, Mr. Brydone's reference to our former paper (p. 127) as "dealing somewhat sketchily with the purely stratigraphical aspect of the Trimingham Chalk on apparently very incomplete data," calls for a few comments, because, like Mr. B. B. Woodward's criticism, with which we briefly dealt in the November number for last year, it involves a question in the method of writing papers which is of some importance. Notwithstanding Mr. Brydone's censure, I venture to remark that the study of fossil polyzoa may not be the best schooling for dealing with questions of physical and stratigraphical geology, and that at any rate we did not need to be informed, after committing ourselves to print, that the magnetic and the true north are some twenty degrees apart. We sought to disprove a particular hypothesis, i.e. that the chalk at Trimingham bluff showed, like a monument, how an ice-sheet could bend and pucker up the rock over which it advanced. After visiting the critical section, at intervals during twelve years, we found that the inroads of the sea had at last provided evidence which, in our opinion, was fatal to Mr. Reid's hypothesis and suggested that a group of erratics existed here as elsewhere on the coast. In stating this evidence, for that particular purpose, we considered (and remain of the same opinion) discussions both of minute palæontological details (interesting in their way) and of previous readings of the coast sections to be equally irrelevant. The new evidence was, in our opinion, unfavourable to the sea-stack hypothesis, so nothing was to be gained, except a waste of time and space, by discussing that. Certainly it was one against which we entertained no prejudice, for, could it have been established, it would have been, in our opinion, fatal to the ice-sheet Frankenstein. If a stack of by no means strong chalk could withstand the monster's ramming and rooting, what becomes of the fjords, lake-basins, and similar results of the "minor fury of ice-foam." That spectre, at any rate, would have been exorcised, melting into mists as it sought refuge in the place of its nativity.

We therefore maintain that as our evidence was new, and the scope of our paper limited, any *précis* of the literature of the subject was both needless and otiose. I will even venture to express a belief that this display of literary research threatens to be exalted into a geological fetish. Disinterring past errors, unless it be necessary to confute them, is a thankless process, and the hunting for mare's nests through dust-covered tomes consumes time that could be much better employed in the study of sections; for the contents of these nests but rarely provide a nutritious mental diet. When consciously indebted to others for a fact or an argument, we

are bound to acknowledge it, but when the one is new or the other not yet accepted, little, I think, is gained by recounting ancient history. "Most votes" (unless intelligent) do not "carry the day" in science as they do in a Parliamentary election, so that even the opinions of the great men of old do not count for much in questions on which they could not be fully informed. Thus I maintain that while a chapter on the past literature is appropriate and even necessary to a complete memoir on any subject, it is useless padding, and even worse, in a paper which aims at either advancing or disproving one of certain views, the existence of which is a matter of common knowledge. Such a chapter is, I believe, rarely remunerative to the reader, and almost never to the writer. I am quite aware that the expression of such an heretical opinion may shock the sensibility of students more at home in the library than in the field, but am prepared to endure with equanimity even the sort of criticism which Mr. Brydone welcomes as effectual.

III.—Tarns on the Haystacks Mountain, Buttermere, Cumberland.

By R. H. Rastall, M.A., F.G.S., Fellow of Christ's College, Cambridge, and Bernard Smith, B.A., Sidney Sussex College, Cambridge.

(With five Text-figures.)

ALTHOUGH the lakes and larger tarns of the English Lake District have been the subject of much discussion and have given rise to a very voluminous literature, comparatively little has been written on the smaller tarns, and especially on those of the very smallest size, which are so abundant in many parts of the district. It seems to us, however, that the smaller ones are quite as deserving of consideration as the larger, since they present similar phenomena, and their interpretation gives rise to similar difficulties.

During an excursion in the autumn of 1903 we happened to come across a group of small tarns which seemed to be interesting in several respects, and we determined to investigate them fully.

These tarns are situated at considerable elevations, 1,600 or 1,700 feet, on the Haystacks, a mountain which separates the head of the Buttermere-Crummock-Water valley from Ennerdale, to the east of Scarth Gap, the usual pass between the two valleys (Ordnance Survey map, six inch, 69 N.E.). The highest part of the mountain very nearly attains the 2,000 feet contour-line near its western end. It consists of lavas and ashes of the Borrowdale series overlying Skiddaw slates: the lag-plane separating the two formations passes below the great crags on the northern side. The volcanic rocks dip with great uniformity to the south-east, striking transversely to the watershed, thus forming a good example of a plagioclinal ridge. The summits are very rugged, and the side towards Warnscale, the head of the Buttermere valley, shows some fine crags, several hundred feet high.

The upper surface of the mountain is extremely irregular, and consists of small peaks and pinnacles, enclosing numerous hollows, in some of which are small tarns and in others extensive peat-bogs.

This upper surface is well glaciated, and the *roches moutonnées* are exceptionally good. The ice has undoubtedly moved from the south-east, down the slopes of Brandreth and Grey Knotts, which form a continuation of the Haystacks ridge in this direction, and reach a considerably higher elevation.

Two of the tarns on this mountain are of considerable size, and there are also one or two much smaller pools which show some interesting features.

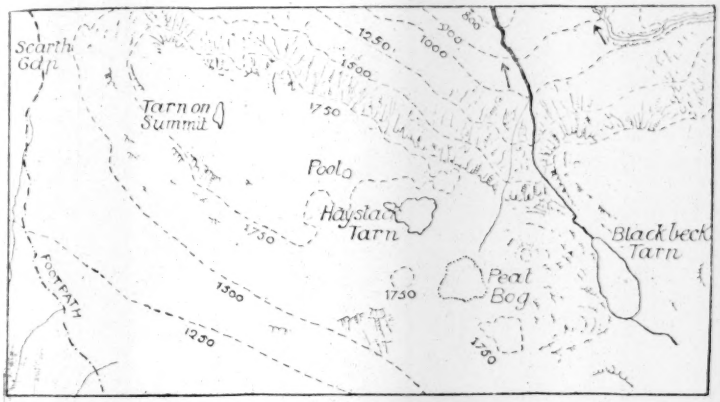


Fig. 1.—Contour Map of Haystacks Mountain, showing position of tarns and peat-bog. Scale 6 inches to 1 mile.

(1) Blackbeck Tarn.—This tarn is the only one which is dignified with a distinctive name on the six-inch Ordnance Map. It is a sheet of water some 250 yards long by 100 yards wide, and is situated towards the south-eastern end of the Haystacks, very near to the edge of the crags, and it drains over the lowest point of the crags into Warnscale.

Fig. 2.—Roche moutonnée, Blackbeck Tarn.

On all sides except towards the outlet the tarn is surrounded by Borrowdale rocks, which show very fine examples of *roches moutonnées*, and one large rock on the west side near the outlet is particularly fine; on the south-east side it is planed away to a smooth surface, which makes an angle of about 15° with the natural planes of separation, as shown in Fig. 2.

At its upper end the tarn is being gradually filled up in the usual manner by stream deltas, but since the gathering-ground is so small this must naturally be a slow process. It seems to be much assisted by vegetation, which is more luxuriant than might be expected at such an elevation.

Turning now to a consideration of the outlet, we find several interesting features. No rock is found *in situ* at or near water-level; it is only at some distance down the stream that we first observed any unmistakable rock in place: this is at least seven or eight feet below the surface of the lake. The narrow outflow valley is filled with rounded mounds, which are very suggestive of moraines, although they contain a good many angular blocks.

Fig. 3.—Outlet of Blackbeck Tarn.

A, C, old gorges; E, large boulder; B, D, present channel higher than at A, C respectively. Scale about 24 inches to 1 mile.

Many of the loose blocks lying on the surface are similar to the rock *in situ* on either side of the outlet. This suggests that the apparent moraine may in reality be scree, or a mixture of scree and rainwash. On the other hand, many of the boulders in the banks of the stream and in the stream itself are totally different from the rocks on either side, or *in situ* lower down the stream, and we were not able to match them in the immediate neighbourhood. The local rock is a fine-grained, cleaved, and slickensided ash, while most of the boulders proper, which are obviously ice- or water-worn, consist of coarse-grained banded ashes or tuffs, which may possibly have come from Green Gable.

The outflow valley, though narrow in comparison with the width of the tarn, is broad in proportion to the size of the stream; it is bounded by steep walls, and below this comes a nearly level surface, which in parts is slightly convex, suggesting the outline of a moraine; the stream runs at the bottom of a slightly meandering gorge, considerably below the level of this surface.

Further down the slope of the sides becomes much steeper, and the depth of the gorge increases greatly. At two points, A and C, are seen portions of former gorge-like channels at a much lower level than the present stream-bed alongside them (see Fig. 3). The lower of these contains an unusually large boulder of banded ash. It seems probable that these deeper gorges are parts of an old pre-Glacial channel, which was filled up by moraine. It is difficult to imagine that sufficient scree material could be derived from the low side-walls of this valley to make any appreciable difference in the level of the stream. The walls of these deeper gorges consist of rock *in situ*, while in the present channel none is seen until we reach a point far below the level of the lake, where the stream cascades over the crags.

Fig. 4.—Cross-sections of the outlet of Blackbeck Tarn, along the lines X–Y and W–Z of Fig. 3.

After careful consideration of all the evidence it seems quite clear that this tarn is not a rock-basin, but is held up by some kind of loose material which blocks the outlet, and we incline to the belief that this material is of the nature of moraine rather than scree.

None of the facts above mentioned throw much light on the past history of the tarn, but it seems very probable that if the old partly buried channel could be cleared out the tarn would be completely drained. Unfortunately we have not, up to the present, been able to obtain any soundings, so that the real depth of the water is unknown: judging from the surrounding slopes, it is not likely to be great.

Although it is not possible, with the evidence at present at our disposal, to be quite certain, we think it highly probable that this tarn is entirely of post-Glacial date, and it is to be regarded as the direct consequence of the damming of a small pre-Glacial valley by morainic material.

(2) Haystack Tarn.—The second tarn on the Haystacks is a good deal smaller than Blackbeck Tarn, but still it is of considerable size, covering approximately one and a half acres. It is without a name on the six-inch Ordnance Map, so as a matter of convenience we have named it Haystack Tarn. This tarn is now evidently being rapidly filled up, as shown by the strong growth of rushes and peaty material. It contains several small islands of rock *in situ*, showing the normal strike of the district, i.e. about E. 30° N. The tarn is

surrounded by very fine *roches moutonnées*, which have evidently been formed by ice advancing from the south, down the slope of Brandreth, from the great gathering-ground which seems to have existed on or near the ridge running eastwards from Great Gable.

The Haystack Tarn at present drains nearly due south, into Ennerdale, by means of a very shallow channel, which looks quite recent; rock may be seen *in situ* in the channel at almost any point, and if there is any moraine or peat in the channel it cannot be more than one foot deep. This tarn, then, evidently drains over rock at the present time.

But closer examination shows that it is not a rock basin. In the north-east corner is a low opening, which seems to be blocked by loose material of some sort, either scree, or more probably moraine. Rock *in situ* with the normal strike and nearly vertical dip can be traced close up to the shore at this point, but not by any means continuously, and there is plenty of room for a buried channel between some of the exposures. This old channel, if such it be, is some ten yards broad, and much resembles the upper part of the present outflow channel of Blackbeck Tarn. The ground rises for a few yards from the water's edge, and the highest level in the centre is some 3 or 4 feet above water-level. The cross-section is a smooth curve of the usual type.

This channel leads down without interruption to a low point in the crags on the northern or Warnscale side, exactly like the outflow of Blackbeck Tarn, and, in fact, in every respect completely resembles one of the numerous small valleys of erosion cut into the rugged surface of this mountain.

We have, therefore, no doubt whatever that this tarn owes its existence to the blocking of this channel by loose material of some sort, either scree or moraine, and it seems to be almost certain that this material is moraine; the sides of the channel are so low that it is almost impossible that they can have given rise to sufficient scree. This argument is even stronger here than in the case of Blackbeck Tarn.

Here, again, what appears at first sight to be a rock basin is shown to be nothing of the kind, but to owe its existence to moraine.

This tarn lies at an elevation of some 1,700 feet and about 100 feet above Blackbeck Tarn. On its south-eastern side, and about 10 feet above it, is a very small pool, which may be a true rock basin, but it is so small as to be unworthy of further notice.

(3) At a much higher level than either of the foregoing, in fact only about 15 feet below the highest point of the Haystacks, lies a small pool which presents some interesting features. It is very small, measuring only about 50 yards in length by 15 in width, and its elevation is nearly 2,000 feet. It seems to be quite deep in comparison with its size. This pool has no outlet at all, even in the exceptionally wet weather which prevailed when we were studying this region (August and September, 1903), and it appears to be surrounded on all sides by rock.

The above concludes our description of the tarns of this mountain, but there still remains an interesting feature to describe.

(4) On the southern side of the mountain and south-east of Haystack Tarn is to be seen a large pool of water of peculiar character, which suggests a possible way of formation of small lake-basins. The greater part of this hollow is at present filled by peat-hag of the usual type, and as usual at various levels in different parts, but the central part has been hollowed out by some means and now forms a fair-sized shallow pool; over a considerable area surrounding this is seen an expanse of bare peat only a few inches above the water-level. It is interesting to note that over this bare expanse are scattered a large number of branches or roots of trees, showing that the peat-hag must be of great antiquity.

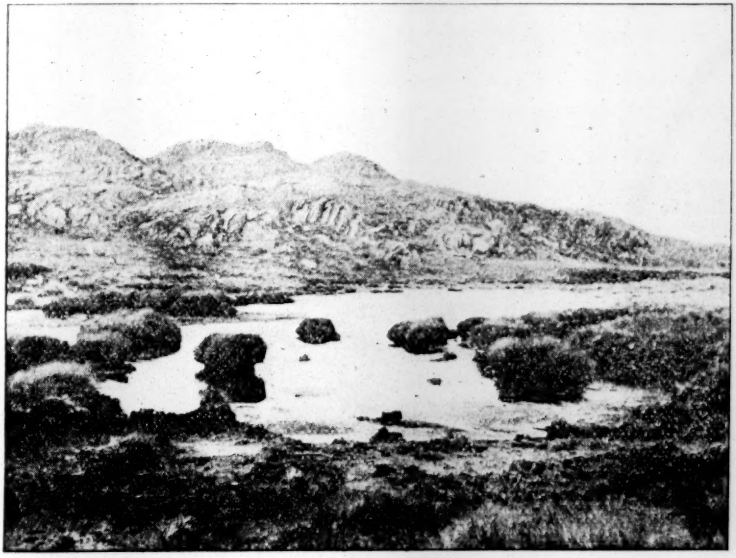


Fig. 5.—Tarn formed by wind-erosion of peat, Haystacks Mountain, Buttermere.

However, the most noticeable feature is the character of the small islands of peat which now project above the water in the pool. These islands are all remarkably undercut and overhanging, and in many cases are penetrated by actual tunnels; in fact, they mimic in a remarkable manner the natural features of a wave-beaten coast, such, for example, as the chalk cliffs of Antrim or Flamborough.

It seems almost certain that this peculiar form has been produced by wave-action, which indeed could be seen almost in active operation at the time of our visit, and it must have been especially potent in such a wet and stormy season as that of 1903. At this great elevation, over 1,800 feet, the wind is nearly always powerful,

and this basin lies in a hollow very near the edge of an exceedingly steep slope into Ennerdale, where wind-action would be accentuated. The pool at present drains towards the north, over an outlet blocked to some extent by scree, instead of to the south, as would naturally be expected.

The life-history of this pool may have been as follows:—An old tarn of the ordinary type, due to moraine or scree, was gradually filled up by the growth of peat, as the present ones are now being filled. By some means, possibly owing to excessive rainfall, water began to accumulate on the surface, and this water under the influence of the wind was gradually able to erode a small basin, which is still much smaller than the original extent of the tarn. This excavation may also be assisted by desiccation and removal of matter as dust during dry periods; thoroughly dry peat is a very light material and easily blown away.

That something of the sort has occurred is quite evident, since the presence of wood on the surface clearly proves removal of peat; the chief difficulty is to account for the first formation of the pool of water on the surface. It is possible that an increase of scree material at the original outflow may have caused so great an accumulation of water that the peat could not soak it all up, and some collected on the surface.

In this case wind-action appears to be the primary cause of the present existence of this pool: whether there ever was a tarn here before is quite immaterial; all that the theory requires is a sufficiently level peat-bog, however formed. In any case some physical change seems necessary to cause a reversal of the usual process of accumulation of peat, but many reasons could be given for such a change, such as blocking of an outlet by landslips or scree, or capture of a larger drainage area by a feeder, and so on.

On the whole this idea seems worthy of consideration as a possible cause of the formation of lake-basins, at any rate, on a small scale; it seems especially likely to occur in cols and narrow passes, where the force of the wind is concentrated.

IV.—The Zones of the Lower Chalk.

By T. O. Bosworth, B.A., St. John's College, Cambridge.

THE object of this paper is to suggest some modification of the present zoning of the Lower Chalk.

I. Disadvantages of using *Holaster subglobosus*.

This fossil is at present supposed to characterise the Chalk between the zones of *Ammonites varians* and *Actinocamax plenus* (= *B. plena*), but its unsuitability is evident from the following summary of its occurrences:—

In Dorset and Devonshire *Holaster subglobosus* occurs in the zone of *Ammonites varians* and is absent from the Chalk above.

In Hampshire, Wiltshire, Isle of Wight, Sussex, and Kent it is nearly as common in the zone of *A. varians* as it is in the beds above. Except in the Isle of Wight, it is not recorded from the upper part of these beds.

In Berkshire, Oxfordshire, Suffolk, and Cambridgeshire, where the zone of *H. subglobosus* is typically developed, it is my experience that the zone fossil is absent from the upper half of the 80 feet of Chalk above the Burwell Rock. It is associated with *A. varians* in the Burwell Rock.

In Lincolnshire and Yorkshire *H. subglobosus* is abundant in the zone of *A. varians*, but so rare in the beds above that *Offaster sphericus* is used as the zone fossil in its stead.

In France *A. rotomagensis* is used as the zone fossil.

II. On the True Position of the Burwell Rock.

This bed appears to have been placed in the *H. subglobosus* zone for two reasons:—

(1) It contains occasional *H. subglobosus*.

(2) There is a lithological change on passing from the Chalk Marl into the Burwell Rock.

These arguments are neither of them sound. Regarding the first, we have seen that *H. subglobosus* is to be expected in the *A. varians* zone, and *A. varians* itself is common in the Burwell Rock. As regards the second, the change is often a very gradual one, and the practice of relying on lithology is only a relic of darker ages. There is quite as great a change on passing up out of the Burwell Rock into the Chalk above. Moreover, grey chalk rock beds of very similar nature are included in the upper part of the *A. varians* zone of Southern England. The fauna of the Burwell Rock is a large one, while those of the Chalk Marl beneath it, and the Chalk above it, are both small. But, of these two, that of the Chalk Marl is more nearly allied to the Burwell Rock fauna than is that of the Chalk above the Burwell Rock.

The fauna of the Chalk Marl of Cambridge and Suffolk, as recorded in the General Memoir,[1] 1903, together with *Nautilus elegans*, which I have found at Mill Road, consists of 4 Cephalopods, 2 Echinoids, 9 Brachiopods, 7 Lamellibranchs, 2 Annelids, and one fish. And of these 25 species, all save *Terebratulina triangularis* and *Serpula amnulata* occur in the overlying Burwell Rock, i.e. 92 per cent. of the species are common to both.

In the Chalk above the Burwell Rock the fauna as recorded in the General Memoir, together with several species not hitherto recorded (to which reference will be made), consists of—

6 Cephalopods,	of which	5	are recorded	from the Burwell Rock;
7 Echinoids	,,	3	,,	,,
8 Brachiopods	,,	8	,,	,,
17 Lamellibranchs	,,	12	,,	,,
1 Annelid	,,	1	,,	,,
2 Polyzoa	,,	0	,,	,,
6 Fishes	,,	4	,,	,,
4 Reptiles	,,	0	,,	,,

i.e., of these 51 species only 33 are recorded from the Burwell Rock; i.e., 67·4 per cent. of the species are common to both.

[1] "General Memoir on the Cretaceous Rocks of Britain," vol. ii (1903).

The Echinoids which are not found in the Burwell Rock are *Cidaris Bowerbankii*, *C. hirudo*, *Echinocyphus difficilis*, and *Holaster trecensis*. The first and last of these are abundant. A large variety of *Discoidea cylindrica* is also common, and seems distinct from the smaller variety recorded from the beds below. The teeth of *Ptychodus decurrens* are common in the Chalk, but very rare in the Burwell Rock.

[The subjoined Diagram (Fig. 1) shows the comparative thickness of the zones under the suggested system. The localities chosen do not lie very far from a mean straight line. The distances between the columns roughly represent the distances between the points on the straight line which most nearly represent the positions of the towns named. Vertical scale is 1 cm. = 30 feet. (The Burwell Rock is indicated in black.)]

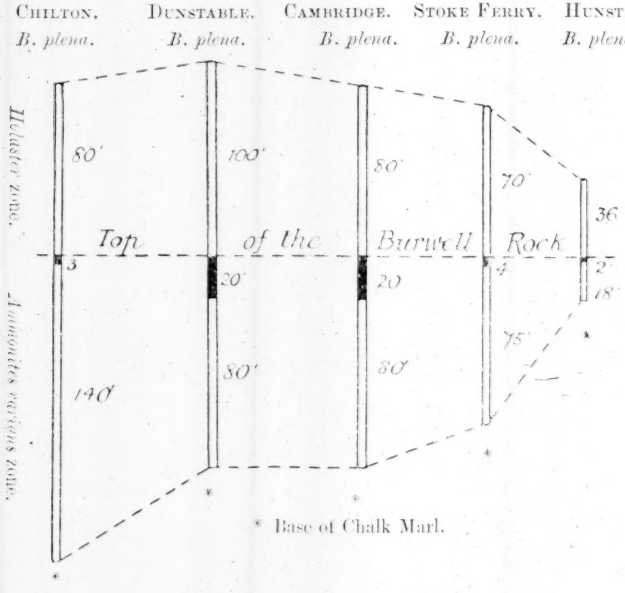


Fig. 1.—Comparative thickness of Zones of the Lower Chalk under suggested system.

Thus there seems to be a much more definite faunal change on passing up *out of* the Burwell Rock than on passing up *into* it. Now the zone of *A. varians* in Southern England contains a very rich fauna, but as we pass north of the Thames the fauna of the Chalk Marl becomes smaller and smaller, while the thickness of the Burwell Rock increases until in Cambridgeshire, where the Burwell Rock has its maximum thickness, the fauna of the Chalk Marl has dwindled down to 23 species. The explanation is that the Burwell Rock is really the most fossiliferous part of the *A. varians* zone, and by placing it in the *H. subglobosus* zone we

endow that zone with an abnormally rich fauna and impoverish that of the *A. varians* zone. The fauna of the Burwell Rock is one typical of the zone of *A. varians*, and is practically identical with that of the shelly beds in the upper part of that zone in Kent.

Of the 16 Cephalopods (including *Baculites baculoides*, not recorded in the General Memoir, but which I find common at Fulbourn), 9 Echinoids, 10 Brachiopods, 11 Gasteropods, 25 Lamellibranchs, and 2 Corals, all occur in the zone of *A. varians* of Southern England, with the exception of *Nautilus reflectus* and 6 Lamellibranchs, of which I can find no record except occurrence at Burwell. *A. varians* itself is more plentiful in the Burwell Rock than in the underlying Chalk Marl.

This figure (Fig. 2) shows the comparative thickness of the zones under the present system :—

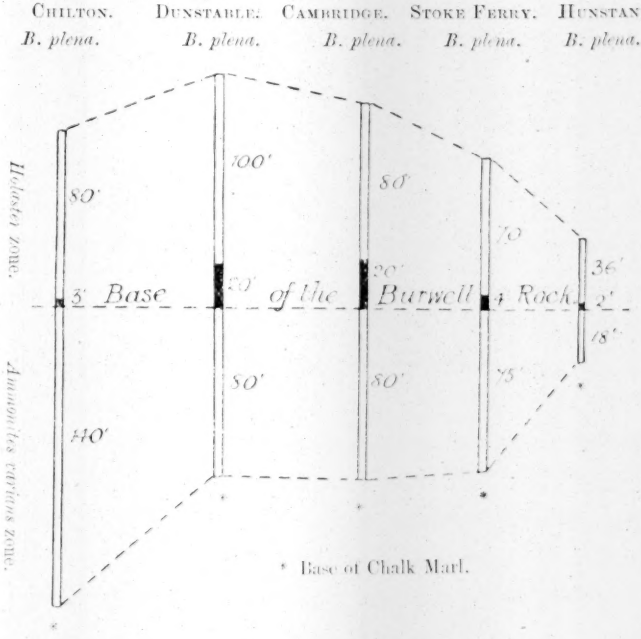


Fig. 2.—Comparative thickness of Zones under present system.

If, on the strength of these arguments, the Burwell Rock be relegated to the *A. varians* zone as a mere facies of Chalk Marl, the thinning of the Lower Chalk towards the north-east is somewhat simplified (see Figure), the thickness of the two zones decreasing more uniformly and simultaneously. The most convenient place to draw the line of separation is the well-marked band of *Rhynchonella Mantelliana*. This occurs a few feet above

the Burwell Rock, and contains the *A. varians* zone fauna. The fossils are extremely numerous in this bed, consisting principally of large specimens of *R. Mantelliana*, *Serpula umbonata*, *Terebratulina nodulosa*, and *Cidaris dissimilis*.

III. On *Holaster trecensis*.

In Dorset and Devon this fossil is plentiful in the beds above the *A. varians* zone, *H. subglobosus* itself being absent. *H. trecensis* is almost confined to the zone and could well be used as the zone fossil.

In Hants, Sussex, Kent, and Isle of Wight, this fossil is common throughout the zone from base to summit, and is only occasionally found in the Chalk Marl.

In Yorkshire *H. trecensis* is not found.

In Lincolnshire *H. trecensis* is found above the Burwell Rock, and it is also recorded from the Chalk Marl, but I do not know whether it is common at that horizon.

In Cambridgeshire *H. trecensis* is not yet recorded except from Shelford, in the General Memoir (op. cit., 1903). But examination of the Lower Chalk of this county during the past three years has shown to me that this fossil is remarkably abundant, being much more common than *H. subglobosus*. In fact, there appear to be two very distinct zones in Cambridgeshire in this 80 feet of Chalk—the upper half (about 40 feet) abounding in *H. trecensis*, but with no *H. subglobosus*; the lower half with *H. subglobosus* and no *H. trecensis*.

I have found *H. trecensis* in the great pit at Cherry-Hinton in the upper part of the Lower Chalk, which has not been worked for many years, also at Shelford in abundance, and most plentifully in the pit on the Golf Links. In this latter locality the zone of *Actinocamax plenus* and the upper 35 feet of the so-called *H. subglobosus* zone are quarried. Fossils are on the whole very scarce, but I have found *H. trecensis in sitâ* from the bottom of the section up to within a foot of the *Actinocamax plenus* (= *B. plena*) zone. I have also had all the fossils from the workmen for the past two years.

The following is a list of the species, with the number of specimens obtained:—

Pisces.	
Otodus appendiculatus (tooth)	1
Ptychodus decurrens ,, ...	3
**Oxyrhina Mantelli* ,, ...	1
Vertebræ and scales	numerous
Crustacea.	
**Enoploclytia Imagei*	very numerous
Echinoidea.	
Holaster trecensis	77
**Discoidea cylindrica*	7
**Cidaris Bowerbankii* (spines)	6
Brachiopoda.	
Terebratula semiglobosa	4

Lamellibranchiata.	
**Diaphana Nilssoni* (= *Plicatula sigillina*) (attached to test of *Holaster*)	2
Ostrea vesicularis	very numerous
**Ostrea filata*	,, ,,
Pecten learevi	7
Inoceramus sp.	3
Spondylus latus	1
**Teredo*, sp. nov. (?)	a group
Polyzoa.	
**Proboscina*	1
**Stomatopora* (?)	numerous
Annelida.	
**Serpula umbonata*	1

Note.—Those marked with an asterisk (*) have not been previously recorded from the "Chalk above the Burwell Rock" of Cambridgeshire and Suffolk.

There are several points of interest about this fauna.

(1) The specimens of *Discoidea* are of very unusual size (base $2\frac{1}{4}$ inches in diameter). I can find no record of any so large as this.

(2) The tubes of *Teredo* are very fine and probably belong to a new species.

(3) The absence of *Rhynchonella*, although abundant in the zone of *B. plena* just above.

(4) No specimen of *Holaster subglobosus* has occurred.

(5) *H. trecensis* is unusually abundant, the test being thin, and taken with the rest of the fauna suggesting deeper water.

(6) *Ostrea filata* here includes two forms previously supposed distinct. The left valves are very abundant, occurring attached to specimens of *Holaster*. They have hitherto been erroneously ascribed to *Ostrea vesiculosa*. An excellent figure may be seen in Dr. S. P. Woodward's paper (Geol. Mag., 1864, p. 114, Plate V). But they have little resemblance to the original *Ostrea vesiculosa* from the Upper Greensand of Warminster described and figured in Sowerby's Mineral Conchology (vol. iv. pl. 369) as *Gryphæa vesiculosa*, and afterwards found to be an *Ostrea*. The right valves have hitherto been referred to as *Avicula filata*, a species described by Etheridge. The type-specimen and three others, all from the Burwell Rock of Burwell, are in the Sedgwick Museum. I find it quite common in the Burwell Rock at Fulbourn.

In the monograph of the "Cretaceous Lamellibranchs of England" Mr. Henry Woods makes the following remark on this species (footnote, p. 61, vol. ii, part 2): "I am unable to accept the generic position assigned to this species by Etheridge; it may be an *Ostrea*."

Though the left valves (*Ostrea vesiculosa*) are so plentiful I have only found two right valves (the so-called *Avicula filata*). But one of these is in position attached to the left valve of the so-called *Ostrea vesiculosa*, which is itself along with several other left valves attached to a specimen of *Holaster trecensis*.

Mr. Woods has closely examined these specimens, and is satisfied that *Avicula filata* and the so-called *Ostrea vesiculosa* are right and left valves of the same shell.

This fossil therefore cannot be called either *Avicula filata* or *Ostrea vesiculosa*, for in the former the generic name is incorrect, and in the latter the specific name already belongs to an entirely different species from Warminster. The obvious course is to call it *Ostrea filata*.

IV. The 'Lower Holaster Zone.'

A brief comparison of the values of the two Holasters for zonal purposes may be made as follows:—

Holaster subglobosus.

(1) Does not often reach the top of its zone.
(2) In the type locality it only reaches half way.
(3) Is sometimes entirely absent from the zone.
(4) Is generally abundant in the zone below.

Holaster trecensis.

(1) Occurs up to the summit of the zone.
(2) Is rarely absent, but in Cambridgeshire does not occur in the lower half of the zone of *H. subglobosus*.
(3) Is very rarely found associated with *A. varians*.

Thus neither of these fossils is really fitted for zonal use, and of the two, *H. subglobosus* is the least suitable. But a fairly satisfactory zone might be defined as the 'Lower Holaster Zone' by using the two Holasters in partnership; for one or other of them is nearly always present in every part of the Chalk which occurs between the zone of *A. varians* and *B. plena* throughout Britain.

The following arrangement of the Chalk of Cambridgeshire is therefore recommended:—

Micraster zones	Upper Chalk and Chalk Rock and *Holaster planus* beds.
Holaster planus zone ...	
Terebratulina lata zone ...	Middle Chalk, Melbourn Rock, and Belemnite Marls.
R. Cuvieri zone	
Inoceramus labiatus zone ...	
B. plena zone	
Two Holasters Zone ...	Chalk with *H. trecensis*. Chalk with *H. subglobosus*.
A. varians zone	Burwell Rock. Chalk Marl.

NOTICES OF MEMOIRS, ETC

I.—British Association for the Advancement of Science. Seventy-Sixth Annual General Meeting, held at York, August 1st to 8th, 1906.

President: Professor E. Ray Lankester, M.A., LL.D., D.Sc., F.R.S., F.L.S., Director of the Natural History Departments of the British Museum.

List of Papers Read in Section C, Geology.

Address by the President (G. W. Lamplugh, F.R.S.).

Professor P. F. Kendall.—On the Geology of the Country round York.

J. W. Stather.—Report of the Committee on Drift Deposits at Kirmington, etc.

W. G. Fearnsides.—On the Lower Palæozoic Series at Pomeroy.

H. Culpin & G. Grace.—Recent Exposures of Glacial Drift at Doncaster and Tickhill.

E. Greenly.—Report of the Committee on the Crystalline Rocks of Anglesey.

H. Brodrick.—On Faults as a predisposing cause for the existence of Pot-holes on Ingleborough.

C. G. Danford.—Notes on the Speeton Ammonites.

J. Parkinson.—The Post-Cretaceous Stratigraphy of Southern Nigeria.

Professor T. W. Edgeworth David, F.R.S.—Occurrence of the Diamond in the Matrix near Inverell, New South Wales.

Dr. F. H. Hatch.—On the 'Cullinan' Diamond.

T. H. Holland, F.R.S.—On a peculiar variety of Sodalite from Rajputana.

J. Lomas, Dr. A. Smith Woodward, F.R.S., H. C. Beasley.—Report of the Committee on the Fauna and Flora of the Trias.

A. Wilmore.—A contribution to our knowledge of the Limestone Knolls of Craven.

Professor E. J. Garwood.—On the Faunal Divisions of the Carboniferous Rocks of Westmoreland.

Dr. Wheelton Hind.—Report of the Committee on Life-Zones in the British Carboniferous Rocks.

Dr. A. Vaughan.—Report of the Committee on the Faunal Succession in the Carboniferous Limestone of the South-West of England.

Dr. Henry Woodward, F.R.S.—Arthropods from the Coal-measures.

A. C. Seward, F.R.S.—The Jurassic Flora of Yorkshire.

A. C. Seward, F.R.S.—Report of the Committee on the Fossil Flora of the Transvaal.

Professor G. A. J. Cole.—The Teaching of Geology to Agricultural Scholars.

Dr. F. A. Bather.—Notes on the "Index Animalium."

F. W. Harmer.—The Glacial Deposits of the East of England.

F. W. Harmer.—'Lake Oxford' and the Goring Gap.

M. B. Cotsworth.—On the Continuous Glacial Period.

Professor J. Milne, F.R.S.—Certain Earthquake-relationships.

Discussion on the Origin of the Trias, opened by Professor T. G. Bonney, F.R.S., and J. Lomas.

Professor T. W. Edgeworth David, F.R.S.—Notes on the Coal-measures of New South Wales.

Professor J. W. Gregory, F.R.S.—The Problems of the Palæozoic Glaciations of Australia and South Africa.

Professor E. Hull, F.R.S.—On an Artesian Boring for the Water-supply of the City of Lincoln from the New Red Sandstone.

Professor T. W. Edgeworth David, F.R.S.—Further Note on the Occurrence of Diamond in New South Wales.

Professor J. W. Gregory, F.R.S.—Report of the Committee on the Correlation and Age of South African Strata.

Professor W. W. Watts, F.R.S.—Report of the Committee on Geological Photographs.

Dr. H. Johnston-Lavis.—Recent Observations at Vesuvius.

R. D. Oldham.—A Criterion of the Glacial Erosion of Lake-basins.

Rev. W. Lower Carter.—Notes on the Glaciation of the Usk and Wye Valleys.

Professor S. H. Reynolds.—A Silurian Inlier in the Eastern Mendips.

Professor P. F. Kendall.—Report of the Committee on the Erratic Blocks of the British Isles.

T. Sheppard.—On a Section of a Post-Glacial Deposit at Hornsea.

W. H. Crofts & Professor P. F. Kendall.—The Plain of Marine Denudation beneath the Drift of Holderness.

Professor S. H. Reynolds.—Igneous Rocks of the district south-west of Dolgelly.

Professor S. H. Reynolds.—A Picrite from the Eastern Mendips.

J. Lomas.—On the form of Carbonate of Lime in Pearls and the Pearl Oyster.

Titles of Papers read in other Sections bearing upon Geology :—

SECTION A.—MATHEMATICAL AND PHYSICAL SCIENCE.

Address by the President (Principal E. H. Griffiths, Sc.D., F.R.S.).

Reports of Committees.

Major E. H. Hills, C.M.G., & Professor J. Larmor, Sec. R.S.—The Irregular Motions of the Earth's Pole : a preliminary graphical Analysis of their causes.

The Hon. R. J. Strutt, F.R.S., opened a discussion on Radio-activity and the Internal Structure of the Earth.

SECTION B.—CHEMISTRY.

G. Beilby.—The Crystallisation of Gold in the Solid State.

T. Jamieson, F.I.C.—Utilisation of Nitrogen in Air by Plants.

SECTION D.—ZOOLOGY.

Address by the President (J. J. Lister, M.A., F.R.I.).—The Life-history of the Foraminifera.

Professor Gary N. Calkins.—The Protozoan Life Cycle.

Report of the Committee on Naples Zoological Station.

Report of the Committee on "Index Animalium."

Report of the Committee on Development of Ophiuroids, etc., at the Marine Laboratory, Plymouth.

Professor E. A. Minchin.—Spicule-Formation.

Dr. C. W. Andrews, F.R.S.—The Milk Dentition of the Primitive Elephants.

Arnold T. Watson.—The Habits of Tube-building Worms.

J. E. S. Moore.—Halolimnic Faunas and the Tanganyika Problem.

A. D. Darbishire.—Preliminary note on a New Conception of Segregation.

SECTION E.—GEOGRAPHY.

Address by the President (the Right Hon. Sir G. T. Goldie, F.R.S.).—Geography and Geology.

Clement Reid, F.R.S.—Changes on the Coasts of the British Isles.

J. Stanley Gardiner.—Report of the Committee for Investigations in the Indian Ocean. The Chagos Islands, Indian Ocean.

J. Parkinson.—The Structure of Southern Nigeria.

John Thomson.—Geographical Photography.

R. N. Rudmose Brown.—The Geography of the South Orkneys and other parts of the Antarctic Region.

Professor A. B. Macallum, F.R.S.—Report of the Committee on the Quantity and Composition of Rainfall and of Lake and River Discharge.

Professor W. B. Bottomley.—The Limestone Caves of Western Australia.

SECTION H.—ANTHROPOLOGY.

Report of the Committee to Investigate the (Prehistoric) Lake-Village at Glastonbury.

J. R. Mortimer.—On the Relative Stature of the Men with Long Heads, Short Heads, and those with Intermediate Heads, in the Museum at Driffield.

Harold Brodrick & C. A. Hill.—On a recently discovered Skeleton in Scoska Cave, Littondale.

F. W. Rudler, I.S.O.—The 'Red Hills' of the East Coast Salt Marshes.

Miss Nina F. Layard.—A Winter's Work on the Ipswich Palæolithic Site.

Rev. R. Scott-Gatty.—Pygmy Flints from Yorkshire and Lincolnshire.

Report of the Committee to conduct Explorations with the object of ascertaining the Age of Stone Circles.

SECTION K.—BOTANY.

Address by the President (Professor F. W. Oliver, M.A., F.R.S.).—The Seed a Chapter in Evolution.

Reports of the Committees on Botanical Photographs, on Peat Moss Deposits, and on the Structure of Fossil Plants.

C. E. Moss, M.Sc.—Succession of Plant-Formations in Britain.

Dr. D. H. Scott.—Some Aspects of the Present Position of Palæozoic Botany.

Professor F. E. Weiss.—On the Occurrence, Distribution, and Mode of Formation of the Calcareous Nodules found in Coal-seams of the Lower Coal-measures.

Miss M. C. Stopes, D.Sc., Ph.D.—On the 'Coal-balls' found in Coal-seams.

Professor F. E. Weiss.—A *Stigmaria* of unusual type.

II.—BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE. MEETING AT YORK, AUGUST 1ST TO 8TH, 1906. PAPERS READ BEFORE SECTION C, GEOLOGY.

THE LOWER PALÆOZOIC ROCKS OF POMEROY. By WILLIAM G. FEARNSIDES, M.A., F.G.S.

The Pomeroy district was originally monographed by Portlock between 1838 and 1845, and has since been neglected. Its lower

Palæozoic succession includes both Ordovician and Silurian rocks, and rests unconformably upon a much older series of hornblendic and pyroxenic gneisses and schists, into which masses of granite were intruded in pre-Silurian time.

The succession may be tabulated as follows:—

C. Corrycroar Group: Tarannon (Gala Facies):—Variable green and grey flags and shales with purple and green grits and conglomerates. (*Undivided.*)

B. Little River Group: Llandovery (Birkhill Facies): Lime Hill Beds:—Black, blocky, micaceous mudstones, with light-coloured calcareous bands. Zone of *Monograptus Sedgwickii* with subzone of *Petalograpti.*—Mullaghnabuoyah Beds:—Variable grey shales and flaggy shales with pyritous spots and a few dark bands. Zone of *Monograptus triangulatus* (sp. ?).—Edenvale Beds:—Smooth, grey shales with black mudstone bands. Zone of *Monograptus tenuis.*—Upper Slate Quarry Beds:—Dark cuboidal mudstones, hard and calcareous. Zone of the *Dimorphograpti.*—Lower Slate Quarry Beds:—Soft, blue-grey, papery, micaceous flags. Zone of *Diplograptus modestus.*—Crocknagargan Beds:—Smooth, grey, pyritous shales. Zone of *Cephalograptus acuminatus.*

A. Desertcreate Group: Ashgillian Drummuck Facies: Upper Tirnaskea Beds:—Smooth, banded, green and dark mudstones. Zone of *Dicellograptus anceps.*—Lower Tirnaskea Beds:—Tough, blocky, calcareous grits. Zone of *Dicellograptus complanatus* and *Phacops mucronatus.*—Upper Killey Bridge Beds:—Soft, calcareous, grey mudstones, with *Remopleurides* and *Diplograptus truncatus.*—Lower Killey Bridge Beds:—Soft, ferruginous blue or yellow mudstones, with many *Trinucleus* and *Ampyx.*—Upper Bardahessiag Beds:—Hard and calcareous flags and grits with *Lichas, Phacops hibernicus, Staurocephalus,* etc., and *Strophomena.*—Lower Bardahessiag Beds:—Softer, uncompacted grits, sandstones, and conglomerates, with large *Strophomena* and occasional *Orthis.*

The Desertcreate Group finds its closest parallels in the Drummuck Beds of Girvan, while the Little River Group is most like the Birkhill shales of Moffat. The whole series is overlain unconformably by the Dingle Beds of the local Old Red Sandstone, and, with the formation, has been folded into a remarkable series of shallow isoclines trending a little south of east and north of west and having a general southerly pitch. The total thickness of Desertcreate and Little River Groups together does not exceed 500 feet.

REVIEWS.

I.—Elements of Mineralogy. By Frank Rutley, F.G.S. Fourteenth edition, revised and corrected. Demy 8vo; pp. 251, viii. (London: Thomas Murby & Co.)

THIS little book forms one of the series of textbooks issued by the publishers to meet the requirements of the Science and Art Department, and its popularity is sufficiently indicated by the fact

that a fourteenth edition has been called for. It treats in concise and simple style of the properties and characters of minerals, and is suited to the needs of those who desire to acquire sufficient knowledge to enable them to identify any specimen that may come into their hands, and are not concerned with the more abstruse questions underlying the phenomena of crystallisation. In the present edition the discussion of the optical properties is based on the ideas put forward by Mr. L. Fletcher in his "Optical Indicatrix," and an excellent chapter on radio-active elements has been added by Mr. E. H. Adye. The author completed the revision of the proof-sheets only just before his lamented death in 1904.

II.—Annals of the South African Museum. Vol. IV, Part 4: The Trilobites of the Bokkeveld Beds. By Philip Lake, M.A., F.G.S. 8vo; pp. 201–220, with 5 plates and 1 text-figure. (West, Newman, & Co., London, 1904.)

As far back as 1856 J. W. Salter gave an account of the Trilobites of the Bokkeveld Beds as an appendix to Bain's paper "On the Geology of South Africa" (Trans. Geol. Soc., ser. II, vol. vii), since which time but little has been added to our knowledge of these South African forms. Dr. H. Woodward described (1873) a remarkable species from the Cock's-comb Mountains (Q.J.G.S., vol. xxix), and Dr. French (1897) figured a *Homalonotus* which he believed to be new (Lethæa Geognostica, Th. i, Bd. ii, Lief. 1).

The fine collection here described includes a number of new forms, of which by far the most remarkable is the gigantic *Homalonotus colossus*, sp. nov.

The author has fortified his views as to the affinities of the species he has described by examining the specimens in the British Museum and in the Museum of the Geological Society of London, which contain Salter's types.

The following species are recognized and described:—

Phacops pupillus, sp. nov.
Ph. arbuteus, sp. nov.
Ph. crista-galli (H. Woodw.).
Ph. Africanus, Salter.
Ph. ocellus, sp. nov.
Ph. impressus, sp. nov.
Ph. (Cryphæus) caffer, Salter.
Phacops (?) sp.
Dalmanites lunatus, sp. nov.
Dalmanites sp.
Proetus maldeus, sp. nov.
Typhloniscus Bainii, Salter.
Homalonotus Herscheli, Murch.
H. querinus, sp. nov.
H. colossus, sp. nov.
H. sp.

The presence of a true *Cryphæus* and of spiny forms of *Homalonotus* indicates that the beds may be referred with certainty to the Devonian, and probably to the lower division of that formation.

Few of the forms have any very near allies in Europe. The Phacopidæ are more closely allied to the forms described from Brazil by J. M. Clarke and from Bolivia by A. Ulrich than to any European ones. A. H. F.

III.—Cambrian Faunas of China. By Charles D. Walcott. From Proceedings United States National Museum, vol. xxx, pp. 563–595. 8vo. (Washington, 1906.)

THIS is the second preliminary paper on the Cambrian Faunas of China. In the first paper (Proc. U.S. Nat. Mus., xxix, Sept., 1905, pp. 1–106) a historical introduction was given along with a list of the species known at the time of publication.

During the summer of 1905 a collection made by Mr. Eliot Blackwelder was received, which came chiefly from the provinces of Shen-si and Shan-si. This collection has afforded a number of new species, but has not added otherwise to the knowledge of these faunas already acquired except as to the occurrence of the genus *Coscinocyathus*.

The full report is expected to be published before the close of the present year (1906).

The association of genera and species is given in the list below (all the species are new):—

Upper Cambrian (Ch'au-mi-tien formation) .....
- Brachiopoda:
  - *Discinopsis sulcatus.*
- Trilobita:
  - *Anomocare*, species undetermined.
  - *Anomocarella irma.*
  - *Ptychaspis bella.*

Middle Cambrian (Ku-shan formation) .....
- Trilobita:
  - *Blackwelderia cilix*, Walcott.
  - *Agraulos regularis.*

Middle Cambrian (Ch'ang-hia (Ki-chou) formation)
- Anthozoa:
  - *Coscinocyathus elvira.*
- Brachiopoda:
  - *Obolus* (*Lingulepis*?), species undetermined.
  - *Yorkia*? *orientalis.*
  - *Orthis* (*Plectorthis*) *agreste*, *O.* (*P.*) *Kichouensis*, *O.* (*P.*) species undetermined.
- Gasteropoda:
  - *Scenella*? *dilatatus.*
  - *Platyceras Willisi.*
  - *Stenotheca*?? *simplex.*
- Trilobita:
  - *Dorypyge Richthofeni levis.*
  - *Agraulos armatus*, *A. nitida*, *A. obscura*, *A. ata*, *A. vicina.*
  - *Agraulos* (?)[1] *capax*, *A.* (?) *mehe.*
  - *Anomocare Bigsbyi*, *A. eriopia*, *A. flava.*
  - *Anomocarella contigua.*
  - *Ptychoparia comus*, *P. inflata*, *P. lilia*, *P. nereis*, *P. unaata*, *P. vesta*, *P.* species undetermined.
  - *Ptychoparia* (?) *maia.*
  - *Ptychoparia* (*Liostracus*) *intermedia*, *P.* (*L.*) *subrugosa.*
  - *Solenopleura pauperata.*
  - *Dolichometopus hyrie.*

The fauna of the Ku-shan shale includes species of *Damesella*, *Dorypyge*, and genera that are typical of the Middle Cambrian fauna, while the fauna of the Ch'au-mi-tien limestone, above the Ku-shan

[1] Interrogation points within parentheses indicate undetermined subgenera.

shale, is more nearly related to that of the Upper Cambrian of North America and North-Western Europe. A. H. F.

[*Note.*—In connection with the Cambrian fauna of China we may refer our readers to two papers: (1) by Mr. G. C. Crick, "On some Straight-shelled Nautiloidea of Cambro-Silurian age from Shantung." Geol. Mag., 1903, pp. 481–485, Pl. XXII and Figs. 1–3; (2) by H. Woodward, "Trilobites from the Upper Cambrian of Shantung," Geol. Mag., 1905, pp. 211–215, and pp. 251–255, Pl. XIII, and Figs. 1, 2.—Edit. Geol. Mag.]

IV.—Geological Survey of India. General Reports (*a*) for the period April, 1903, to December, 1904; (*b*) for the year 1905. By T. H. Holland, F.R.S., Director. Records, vol. xxxii, parts 3, 4; vol. xxxiii, parts 1–3. 8vo. (Calcutta, 1905–6.)

THE Director's Reports show the very considerable amount of work carried on by the Survey under his supervision, and the efficient manner in which it is administered. Much is done in connection with the economic functions of geology as well as in its more strictly scientific sphere. We may refer in the former connection to inquiries relating to the occurrence of coal in beds of Tertiary age in the Jammu State (Rec. xxxii, 4), and to the solution of engineering problems, which depend on the nature of local geological formations; these include questions relating to tunnelling and landslips, the effects of railway cuttings on hill-slopes, and other kindred subjects. Much attention is also bestowed upon economic minerals and water-supply. In the scientific field of investigation additions are made from time to time to that magnificent series of scientific memoirs known as the *Palæontologia Indica*, in which the most skilled observers of whatever nationality take part. Palæontological contributions of less bulk and importance find a place in the "Records." Among these are the following: "Notes on the Anthracolithic Fauna from the Mouth of the Subansiri Gorge, Assam," and "The Triassic Fauna of the Tropites-Limestone of Byans, Central Himalayas of Kumaon," both by Professor C. Diener, of Vienna. The last-named paper will appear in an extended form in the *Palæontologia Indica*. Mr. G. E. Pilgrim contributes a paper "On the occurrence of *Elephas antiquus* (*Namadicus*) in the Godavari Alluvium." Both papers are contained in the "Records," xxxii, pt. 3.

In the General Report by the Director for 1905 we find first a description of the routine work of the museum and laboratory, and then a summary of publications in progress, and other matters coming within the scope of the Survey. Among palæontological papers is one by Mr. F. R. Cowper Reed on the fossils of Lower Palæozoic age from the Northern Shan States, with descriptions of the Cystideans by Dr. F. A. Bather, and of the Graptolites by Miss G. L. Elles, D.Sc. Professor C. Diener's services are again in request to describe the Triassic fossils collected by Mr. E. Vredenburg in shales occurring in the Pishin district of Baluchistan. The fossils

(*Monotis* and *Halorites*) indicate the correlation of these beds with the *Monotis*-beds of Spiti and the Alaunic (Middle Noric) sub-stage of the Alpine Upper Trias.

An exhaustive memoir on the Foraminifera of the Indian Tertiary by Mr. Vredenburg is to appear in the *Palæontologia Indica*. The Nummulitic fauna is said to be a very rich one, nearly all the most important types being represented in it. Many interesting points relating to the zoological aspects of the group will also be brought to light.

Mr. Fermor's petrological studies of the Deccan Trap formation point to the important conclusion that the basalts and rhyolites of Pavagad Hill (Bombay) are genetically related to one another.

Under "Seismology" special reference is made to the destructive earthquake in the Kangra valley on the 4th April, 1905. A compilation of the results of inquiries relating to it that were set on foot by the Survey immediately after the event is published in vol. xxxii of the "Records." A. H. F.

OBITUARY.

PROFESSOR J. F. BLAKE, M.A., F.G.S.

Born April 3, 1839. Died July 7, 1906.

The Rev. John Frederick Blake, M.A., F.G.S., who died on July 7th, 1906, at his residence, 35, Harlesden Gardens, N.W., was born at Stoke-next-Guildford on the 3rd April, 1839; he was son of the Rev. Robert P. Blake, and married in 1866 the youngest daughter of the Rev. F. F. Haslewood, Rector of Smarden, Kent. J. F. Blake was educated at Christ's Hospital, London, gaining the first prize medal in Mathematics in 1852, and at Caius College, Cambridge, where he was Senior Scholar and Prizeman in various subjects, and a pupil from 1859–1862 of the illustrious Professor Sedgwick. In 1862 he took his B.A. degree as fifteenth Wrangler, and was first of that year in the Natural Science Tripos. In the same year he edited, in conjunction with the late Prebendary W. A. Whitworth and other representatives of Cambridge, Oxford, and Dublin Universities, a journal known as the *Messenger of Mathematics*, promoted to encourage original investigation, and to unite in style and selection of subjects the three schools, with the view of forming an undivided English School of Mathematics. Ordained at Lincoln Cathedral, Blake became Curate of Lenton, Nottingham, 1862–4, and subsequently held for a short period the curacy of St. Mary's, Bryanston Square, London. In 1865 he was appointed Mathematical Master and Assistant Chaplain at St. Peter's School, York, where he remained for nine years. Among his pupils who have since distinguished themselves may be mentioned: the Rev. P. Braithwaite, appointed Dean of Jersey 1888; H. Tomlinson, F.R.S.; A. T. Pollard, Head Master of the City of London School; G. H. Pickersgill, M.P.; W. Y. Fausset, Head Master of

Ripon School; and Dr. Alan Gray, the eminent musician and organist of Trinity College, Cambridge. In 1874 he gave up clerical work in order to devote himself specially to science, and left York for London. Soon afterwards, at the request of Professor Hughes, of Cambridge, he undertook the Science Lectures for a term at Aberystwith College. From 1876 to 1880 Blake was Lecturer on Comparative Anatomy at Charing Cross Hospital, and in 1878–9 he delivered the course of lectures on the same subject at King's College for the late Professor A. H. Garrod. He was an Examiner for the Civil Service Commission in Geology and Mathematics, and for many years Assistant Examiner in Physiography for the Science and Art Department. Until quite recently he was an Honorary Examiner in Geology to the City of London College, Moorfields. In 1877 Blake was awarded by the Council of the Geological Society the 'Murchison Fund,' in recognition of his original researches, chiefly in Palæontology and Stratigraphical Geology.

The Government Grant Committee recommended Professor Blake for several grants in aid of his work on the British Palæozoic Cephalopoda, and also in aid of stratigraphical researches on the Jurassic rocks of the Continent as compared with those of Britain.

In 1880 he was appointed Professor of Natural Science at University College, Nottingham, and Curator of the Museum, where he remained for eight years. Here he inaugurated and became first President of the Students' Association, and editor of the College "Record." In 1888 he again removed to London, and soon became actively engaged in bringing out the "Annals of British Geology," which ran into four volumes, 1890–1893. Owing to his acceptance of an appointment to equip and arrange the State Museum at Baroda, he was obliged to relinquish this work, and in the winter of 1895 he sailed for India. It was during his temporary absence from England that he met with the great calamity of his life in the loss of his wife, which occurred when they had been parted only two months.

In recognition of the valuable services rendered to Geology and Palæontology during a period of almost a quarter of a century, he was in 1895 awarded the Lyell Medal by the Council of the Geological Society. In 1891–2 he was President of the Geologists' Association, and at the time of his death a Vice-President. He was elected President of the Metropolitan Scientific Association, 1889, and of the London Amateur Scientific Society, 1890 and 1891. Professor Blake conducted many excursions of the Geologists' Association; and the enthusiasm and vigour which he displayed were remarkable. He served on the Council of the Geological Society, and was for some time Editor of the Proceedings of the Geologists' Association. As a member of the International Geological Congress, he attended the meetings held in Philadelphia, London, Switzerland, and Russia. At the London meeting of 1888 he conducted a party of the members through North Wales and over Snowdon. He seldom missed the meetings of the British Association, and read many papers in the Geological Section. Professor Blake was present at the Montreal meeting in 1884, and undertook by himself a difficult journey to

the Rocky Mountains. His impressions of the district are embodied in a paper read at the meeting.

The more noteworthy of Professor Blake's contributions to geological science were those on the Kimmeridge Clay and Portland Beds, and that, prepared conjointly with Mr. Hudleston, on the Corallian rocks—papers that have become classic in the literature of British geology. It is much to be regretted that the monograph on the Fauna of the Cornbrash, on which he was engaged up to the time of his death, was not completed by the author.

Blake was not averse to geological battles, and he entered into sundry controverted matters with characteristic energy, but occasionally with more zeal than discretion. Thus he dealt with (what were at the time) the thorny subjects of the Pre-Cambrian rocks of St. David's, the North-West Highland problems, the Oligocene of the Isle of Wight, and the older rocks of North Wales.

With regard to Professor Blake's work in Anglesey, one who has had occasion to follow it in detail writes:—It seems hardly to have met with the recognition that it deserves. That he erred on certain points is true, but in regions such as Anglesey who has not? The "Monian System" did not, indeed, find general acceptance, but what Pre-Cambrian system has? On the other hand, his principal sub-divisions, as such, hold good for the most part. He discovered the Glaucophane Schist. He discovered the Variolite. These facts alone are enough to show how great an advance his work represents in our knowledge of the older rocks of Anglesey.

He leaves a family of three sons and one daughter to mourn his loss, the eldest of whom is Demonstrator of Chemistry in Queen's College, Belfast, and a Public Analyst in Ireland.

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"The Geological Results of Arctic Exploration." 12mo; London, 1878.
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"Annals of British Geology." 4 vols., 1890–93; London (Dulau & Co.).
"Catalogue of Type- and other Specimens in the Museum of the Geological Society." 8vo; London, 1902.
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GEORGE FREDERICK HARRIS, F.G.S.

BORN SEPTEMBER 13, 1862. DIED JULY 16, 1906.

As supplementary to the short notice given in our last number (p. 384), we may mention that Mr. Harris was born at Anglesey in Hampshire, and educated at Netherhampton House School, Wilton, near Salisbury. He subsequently attended classes at King's College, London, and the Birkbeck Institution. At an early age he became interested in geology and archæology, and he enlarged his knowledge during extensive travels in Europe and during visits paid to North Africa and the United States.

To the GEOLOGICAL MAGAZINE he contributed papers on "The Gelinden Beds," 1887, p. 108; on "The Geology of Gironde," 1890, p. 22; and "A Journey through Russia," 1898, pp. 9, 110.

In conjunction with Mr. H. W. Burrows, A.R.I.B.A., F.G.S., he published a valuable account of "The Eocene and Oligocene Beds of the Paris Basin," with geological map and sections, and numerous lists of species and localities, pp. 1–129, 8vo (read before the Geologists' Association, April 3, 1891, and published separately, E. Stanford, price 3*s.*).

He added an Appendix to Mr. R. B. Newton's Systematic List of British Oligocene and Eocene Mollusca in the British Museum (1891), and prepared a catalogue of the Tertiary Mollusca of Australia[1] in the Geological Department (1897), 8vo, pp. 26 and 408, with 8 plates, printed by order of the Trustees of the British Museum. In conjunction with Mr. Burrows he also named and arranged the Foreign Tertiary Mollusca in the Geological Department of the British Museum.

Mr. Harris was for more than 20 years a regular contributor to the *Builder*, and wrote a series of articles upon "Building Stones," which were afterwards published separately. His attention thus became directed to questions of practical geology. He issued in 1888 a work entitled "Granites and our Granite Industries," and wrote on London Water Supply (1892); he contributed for

[1] Intended to be one of a series.

many years to the *Clayworker*, and published in 1897 a work on "The Science of Brickmaking." While largely engaged on economic questions he carried on investigations into the structure of oolitic freestones (1895), and found time likewise to write occasional papers on Eocene and Oligocene Mollusca in conjunction with his friend Mr. R. Bullen Newton.

RICHARD GLASCOTT SYMES, M.A.

BORN MAY 8, 1840. DIED JULY 27, 1906.

SON of Glascott Symes, M.D., a leading physician of Kingstown, in the county of Dublin, R. G. Symes was born in that town, graduated as Master of Arts and Licentiate of Engineering in Trinity College, Dublin, qualifying for the Mechanical Section of his degree at the Inchicore works of the Great Southern and Western Railway.

Having become interested in geology, he joined the Geological Survey of Ireland as Assistant Geologist under Jukes in 1863. In the course of his work he entirely surveyed six of the one-inch maps and portions of seventeen in conjunction with other members of the staff. Though his earliest work was carried out over forty years ago, his lines as then drawn remain unaltered, though some of the districts he completed, such as that of Lough Conn in Sheet 64, were of a very complicated nature. His latest Irish work was in county Antrim, which he was detailed to examine on account of his practical knowledge of the coal and iron deposits. It is especially satisfactory to note that recent exploration of the Ballycastle Coalfield has entirely justified the indications of his map and six-inch section. In 1869 Symes was promoted to the rank of Geologist. In 1874 he was one of the Secretaries of Section C at the Meeting of the British Association in Belfast, and in 1878 one of the Secretaries of Section G (Mechanical Science) at the Meeting in Dublin. His descriptive memoirs of the Irish areas he surveyed were interesting and clear, and his mapping and draughtsmanship of more than ordinary merit.

Upon the completion of the one-inch Geological Map of Ireland in 1890 he was transferred to the Scottish branch of the Survey, where he surveyed considerable portions of Kintyre and the neighbourhood of Oban in the Argyll district.

He was an ardent sportsman and keen observer of the fauna of the districts in which he was successively engaged, and there were few better practical authorities upon the birds and fishes of Ireland.

Injuries sustained by a car accident whilst engaged some years ago in surveying the country near Campbelton, N.B., shattered a previously robust frame. He retired from the public service in 1900, and settled in Monkstown, near Dublin, where he died on the 27th of July, after a short illness. R. C.

Erratum.—The number of the Plate (Plate XXI) used in the Geological Magazine for July, 1906, in illustration of Mr. Bernard Hobson's article, p. 312, was by an oversight *duplicated* in Dr. Wheelton Hind's and Mr. J. T. Stobbs' paper (Plate XXI), September Number, p. 394. Will readers have the kindness to mark that in the July Number as Plate XXIa, and that in the September Number as Plate XXIb: this will avoid the confusion which might otherwise arise. A reference to these duplicate numbers will of course be made in the list of plates in the December Number.—Edit. Geol. Mag.